



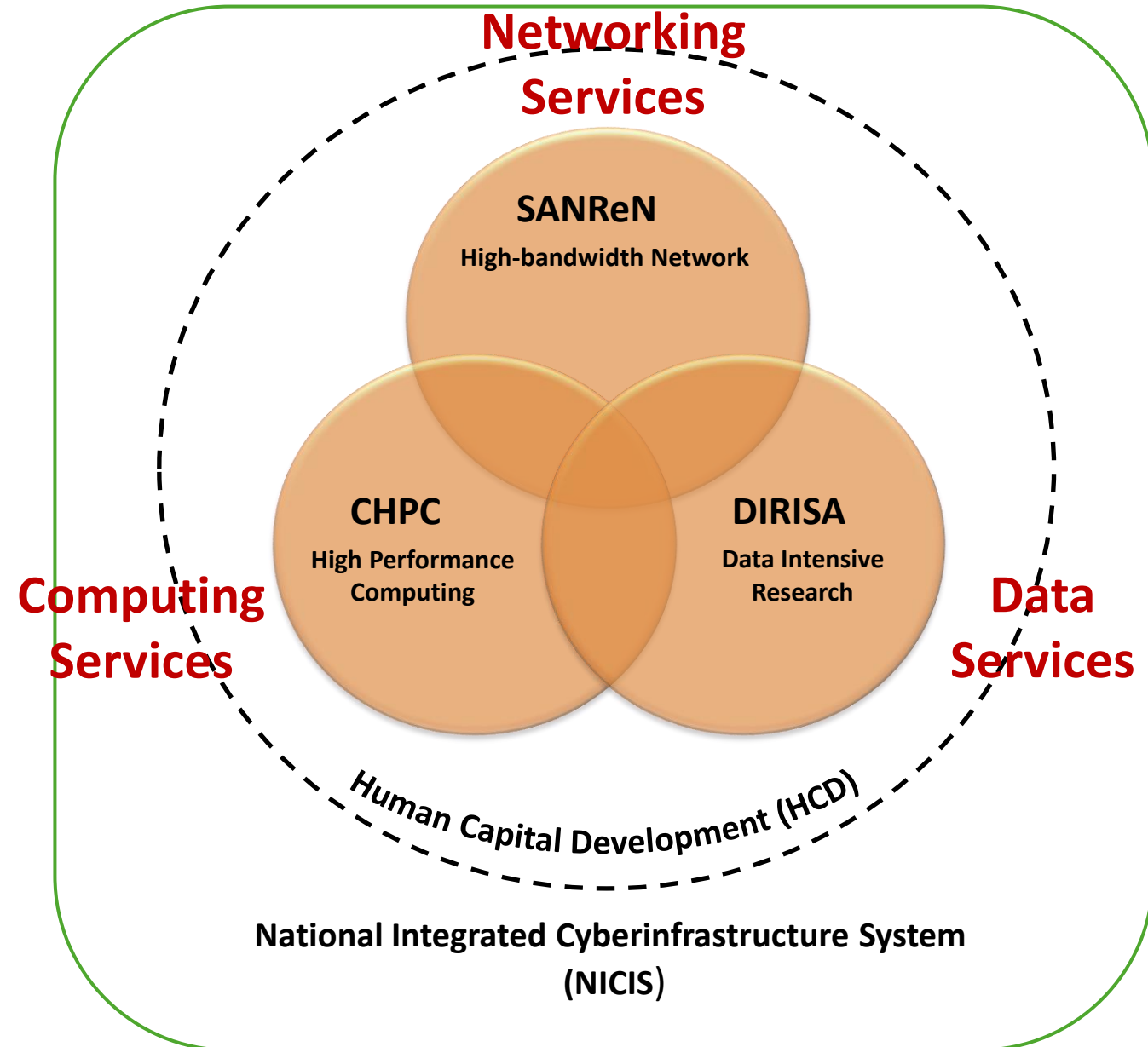
# Hardware is not enough!

Mthetho Vuyo Sovara  
Senior Research Engineer  
CSIR

# Introduction: NICIS

- **N**ational **I**ntegrated **C**yber**I**nfrastructure **S**ystem (NICIS)
- Structure:
  - South African National Research Network (SANReN)
  - Centre for High Performance Computing (CHPC)
  - Data Intensive Research Initiative of South Africa (DIRISA)
  - HCD encompasses the 3 pillars
- NICIS is a hosted programme of the DSTI
- Hosted at the CSIR as a centre in NGEI Cluster, Smart Society Division

SANReN, <https://www.sanren.ac.za/>  
CHPC, <https://www.chpc.ac.za/>  
DIRISA, <https://www.dirisa.ac.za/>



# ***Introduction to CHPC – Computing Capability***

- ***Digital Research Infrastructure***

- High-Performance Computing Cluster
- GPU Cluster
- Localized Cloud Platform
- Tier 2 Node facility (CERN)

- ***Collaborations***

- Large-Scale Science Projects
  - SKA/SADC – HPC Ecosystems Project
  - CERN – ALICE Collaboration
- Localized Cloud Projects
- SARAO / SAWS

- ***Partnering with Emerging and Disruptive Technology Communities***

- Quantum Computing Community
- Deep Learning, AI and ML Community

- ***Training and Skill Development***

- ***Highly Skilled and Dedicated TEAM***

- ***New HPE 4 PFlop System (2026 Deployment)***

- ❑ LENGAU: A NATIONAL ASSET FOR R&D
- ❑ Lengau cluster since **7 March 2017** (First phase June 2016)
- ❑ Africa's first Petascale system  $\Rightarrow$  **1.029 PFlops = 1 029 TFlops**

Deployed in 2016/17  
Debut at 121 on Top500

**Special Nodes**

- 5 High memory nodes
- 30 GPU nodes

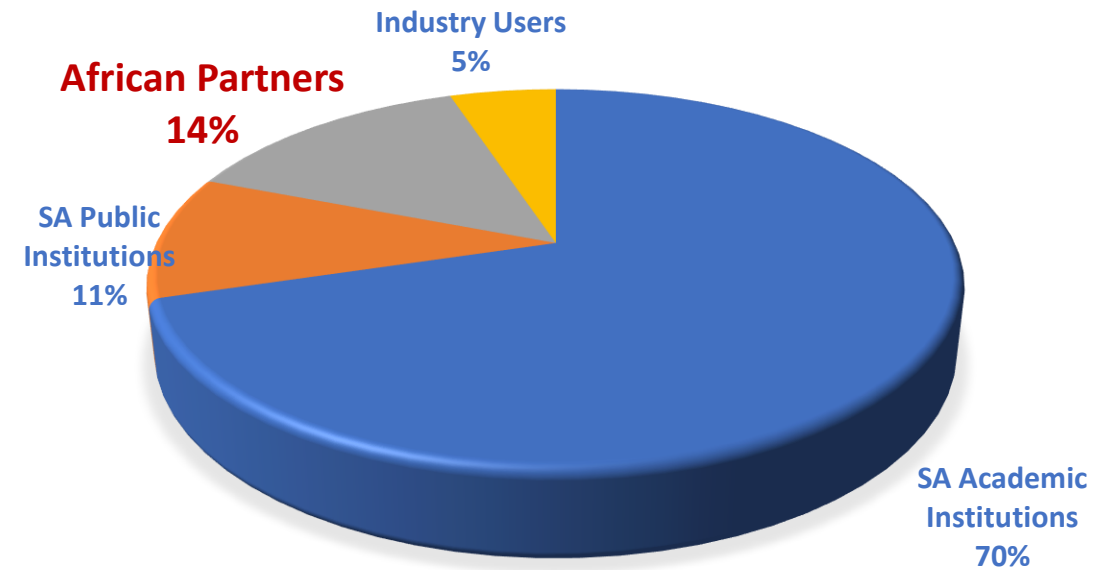
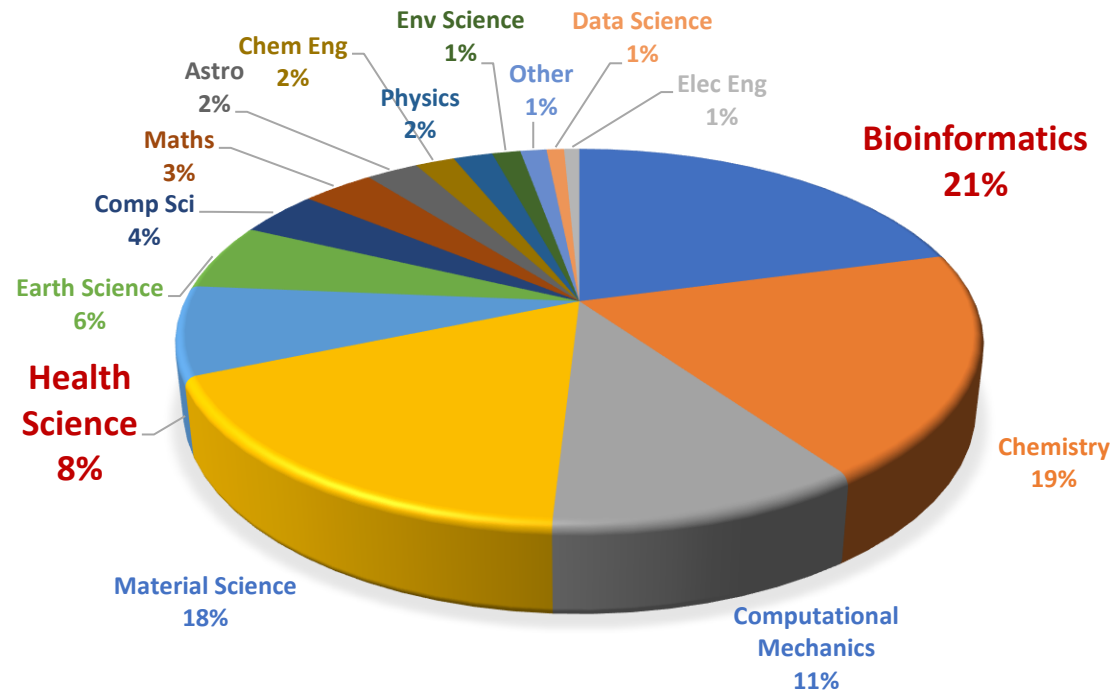
**Lengau (HPC Cluster)**

- 1386 nodes
- 32 832 cores
- 30 V100 GPUs
- 56Gbps IB interconnect
- 4PB Lustre storage
- ~1Pflop/s HPL

(121<sup>st</sup> on Top500\* – June 2016)  
(127<sup>th</sup> on Top 500\* – June 2017)

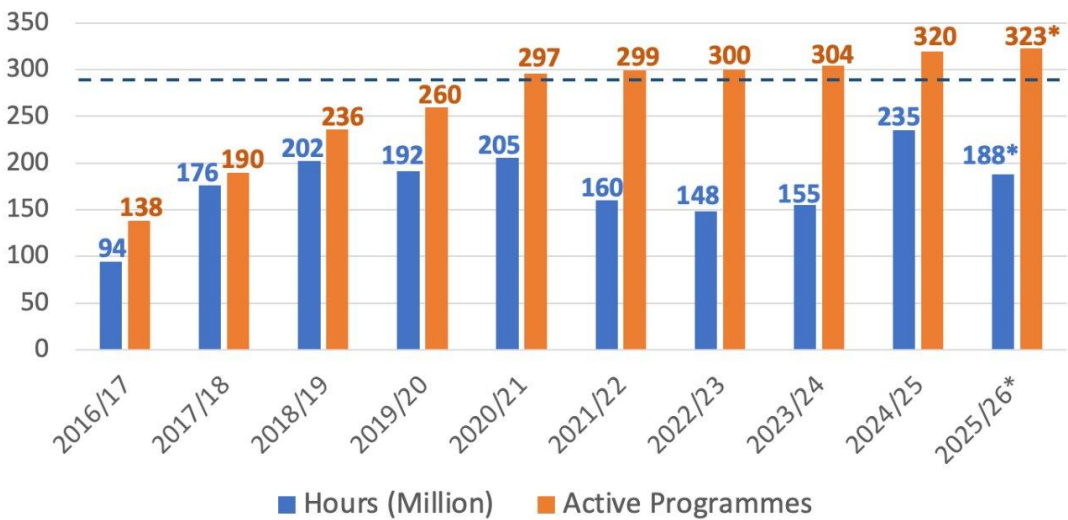


# *The Invisible Layer*



# Total number of peer-reviewed publications reported by CHPC Lengau Research programmes

| FY       | # Publications |
|----------|----------------|
| 2023/24  | 689            |
| 2024/25  | 565            |
| 2025/26* | 509            |
| TOTAL    | 1763           |



Total Number of Active Research Programmes on Lengau Cluster in 10 Year Period: 2016/17 to 2025/26\*:

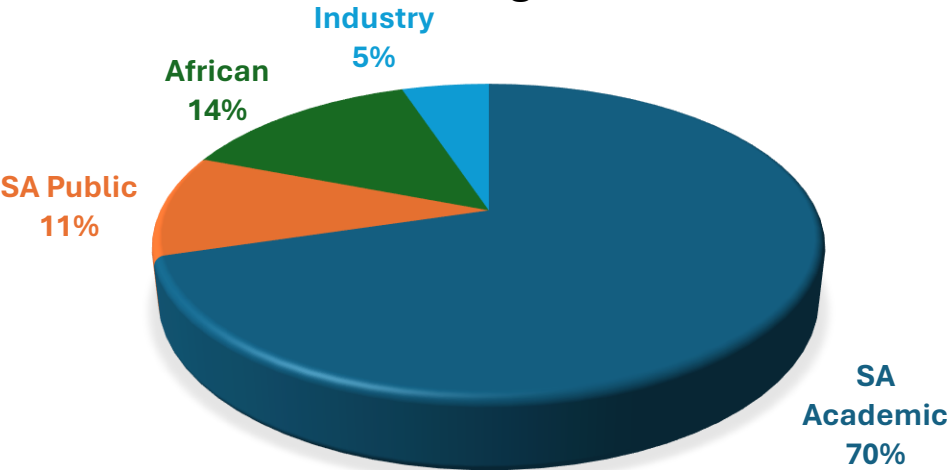
|             | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26* | TOTAL |
|-------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|-------|
| SA Academic | 102     | 139     | 172     | 187     | 219     | 210     | 206     | 207     | 230     | 229      | 495   |
| SA Public   | 21      | 25      | 30      | 34      | 27      | 30      | 31      | 34      | 32      | 34       | 81    |
| African     | 7       | 16      | 23      | 25      | 33      | 39      | 44      | 44      | 43      | 46       | 65    |
| Industry    | 8       | 10      | 11      | 14      | 17      | 20      | 19      | 19      | 15      | 14       | 43    |

Total Hours (Millions) Used on Lengau Cluster in 10 Year Period: 2016/17 to 2025/26\*:

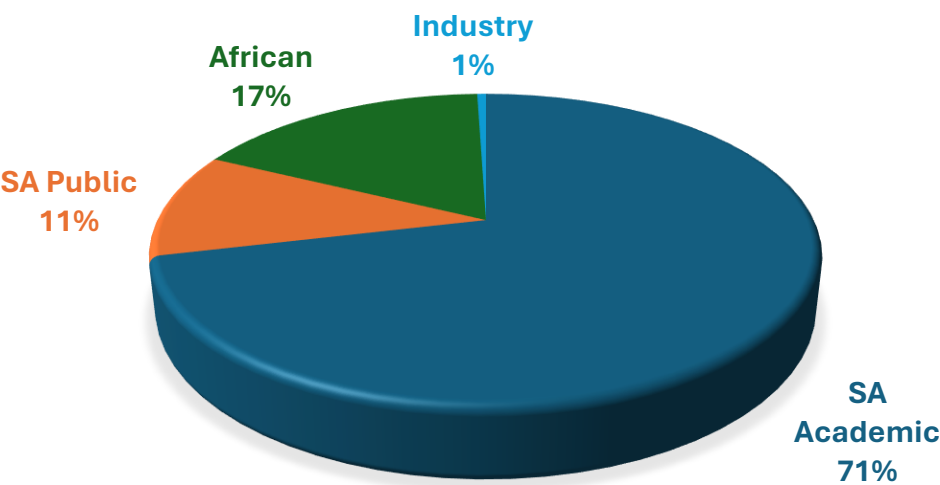
|             | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26* | TOTAL |
|-------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|-------|
| SA Academic | 73      | 140     | 159     | 153     | 161     | 130     | 119     | 111     | 167     | 133      | 1349  |
| SA Public   | 19      | 24      | 25      | 11      | 14      | 6       | 7       | 12      | 26      | 25       | 169   |
| African     | 2       | 10      | 17      | 25      | 27      | 22      | 21      | 31      | 41      | 28       | 226   |
| Industry    | 0.8     | 2.3     | 1.6     | 2.5     | 2.7     | 1.4     | 1.0     | 1.1     | 0.8     | 1.0      | 15.1  |

User Categories on the CHPC Lengau Cluster over 3-Year Contract: 2023/24 – 2025/26\*

Active Research Programmes:



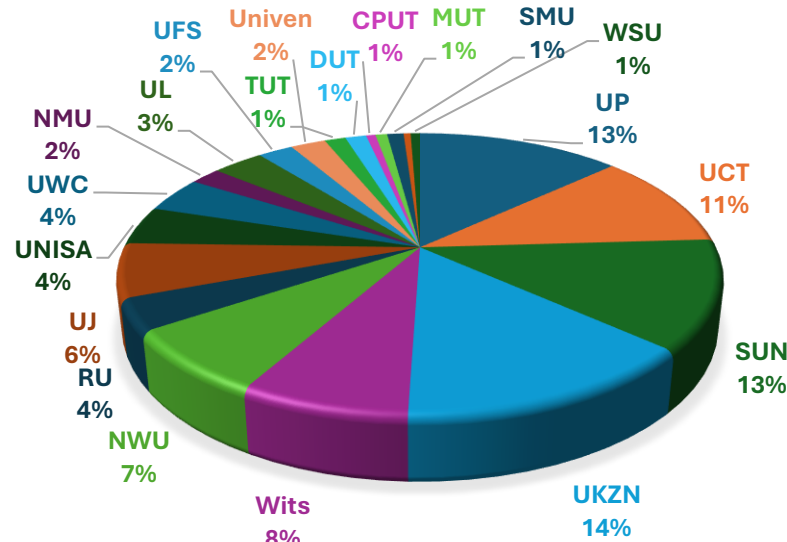
Hours Used (Millions):



2025/26\*: The values only reflect 10.5 months, i.e. 1 Apr 2025 – 19 Feb 2026

## SA Universities Research Programmes on Lengau Cluster in 10 Year Period: 2016/17 to 2025/26\*:

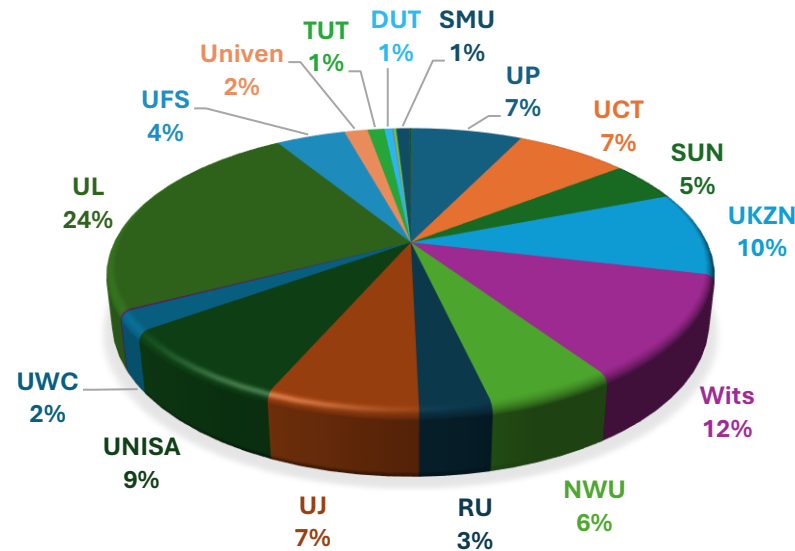
|         | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26* | TOTAL |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|-------|
| UP      | 19      | 29      | 34      | 30      | 33      | 28      | 30      | 26      | 31      | 30       | 79    |
| UCT     | 16      | 22      | 26      | 23      | 29      | 25      | 23      | 20      | 26      | 26       | 71    |
| SUN     | 12      | 15      | 21      | 29      | 25      | 27      | 27      | 27      | 31      | 25       | 68    |
| UKZN    | 13      | 19      | 25      | 25      | 32      | 28      | 26      | 30      | 28      | 34       | 53    |
| Wits    | 5       | 7       | 7       | 9       | 15      | 16      | 15      | 17      | 17      | 17       | 40    |
| NWU     | 6       | 7       | 9       | 8       | 12      | 16      | 18      | 13      | 16      | 20       | 34    |
| RU      | 8       |         |         |         |         |         | 9       | 7       | 9       | 8        | 24    |
| UJ      | 5       |         |         |         |         |         | 14      | 13      | 15      | 13       | 23    |
| UNISA   | 3       |         |         |         |         |         | 6       | 9       | 10      | 10       | 16    |
| UWC     | 3       |         |         |         |         |         | 7       | 9       | 10      | 8        | 16    |
| NMU     | 3       |         |         |         |         |         | 6       | 5       | 4       | 4        | 11    |
| UL      | 2       |         |         |         |         |         | 4       | 6       | 8       | 8        | 10    |
| UFS     | 2       |         |         |         |         |         | 3       | 6       | 4       | 5        | 10    |
| Univen  | 1       |         |         |         |         |         | 5       | 4       | 4       | 7        | 8     |
| TUT     | 1       |         |         |         |         |         | 4       | 4       | 2       | 3        | 7     |
| DUT     | 1       |         |         |         |         |         | 2       | 3       | 4       | 2        | 4     |
| CPUT    | 0       |         |         |         |         |         | 1       | 1       | 1       | 2        | 3     |
| MUT     | 0       |         |         |         |         |         | 1       | 2       | 1       | 2        | 3     |
| SMU     | 0       |         |         |         |         |         | 3       | 2       | 3       | 2        | 3     |
| UniZulu | 0       |         |         |         |         |         | 0       | 0       | 2       | 1        | 3     |
| WSU     | 1       |         |         |         |         |         | 1       | 1       | 2       | 1        | 2     |
| VUT     | 1       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0        | 1     |



**Research Programmes per SA  
University on the CHPC Lengau  
Cluster over 3-Year Contract:  
2023/24 – 2025/26**

## SA Universities Hours Used (Millions) on Lengau Cluster in 10 Year Period: 2016/17 to 2025/26\*:

|         | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26* | TOTAL |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------|-------|
| UP      | 6       | 15      | 22      | 12      | 16      | 10      | 8       | 9       | 11      | 9        | 119   |
| UCT     | 13      | 17      | 18      | 17      | 17      | 14      | 11      | 7       | 11      | 12       | 137   |
| SUN     | 2       | 7       | 7       | 11      | 9       | 8       | 8       | 6       | 8       | 4        | 71    |
| UKZN    | 13      | 22      | 19      | 10      | 9       | 9       | 9       | 10      | 17      | 12       | 129   |
| Wits    | 14      | 17      | 17      | 15      | 10      | 4       | 6       | 9       | 28      | 12       | 132   |
| NWU     | 5       | 10      | 17      | 9       | 19      | 13      | 9       | 8       | 11      | 4        | 105   |
| RU      | 4       |         |         |         |         |         | 12      | 8       | 3       | 3        | 126   |
| UJ      | 3       |         |         |         |         |         | 9       | 7       | 12      | 10       | 69    |
| UNISA   | 1       |         |         |         |         |         | 11      | 11      | 11      | 13       | 113   |
| UWC     | 0       |         |         |         |         |         | 6       | 4       | 3       | 2        | 34    |
| NMU     | 2       |         |         |         |         |         | 0       | 0       | 0       | 0        | 12    |
| UL      | 5       |         |         |         |         |         | 18      | 19      | 39      | 40       | 215   |
| UFS     | 0       |         |         |         |         |         | 6       | 5       | 7       | 7        | 45    |
| Univen  | 1       |         |         |         |         |         | 2       | 4       | 1       | 1        | 17    |
| TUT     | 0       |         |         |         |         |         | 3       | 2       | 1       | 1        | 8     |
| DUT     | 3.6     |         |         |         |         |         | 0.5     | 0.5     | 1.1     | 0.6      | 7.4   |
| CPUT    | 0.00    |         |         |         |         |         | 0.03    | 0.03    | 0.08    | 0.08     | 0.22  |
| MUT     | 0.0     |         |         |         |         |         | 0.1     | 0.1     | 0.4     | 0.3      | 1.2   |
| SMU     | 0       |         |         |         |         |         | 0       | 0       | 2       | 2        | 4     |
| UniZulu | 0.00    |         |         |         |         |         | 0.00    | 0.00    | 0.01    | 0.04     | 0.05  |
| WSU     | 1.17    |         |         |         |         |         | 0.00    | 0.00    | 0.07    | 0.18     | 2.89  |
| VUT     | 0.01    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 0.00     | 0.01  |



**Hours (Millions) used per SA  
University on the CHPC Lengau  
Cluster over 3-Year Contract:  
2023/24 – 2025/26**

# CHPC Use: Industry *Total Active\* Programmes*

*(Full Lengau*

*Lifetime*

*Apr 2016 - 15 Aug*

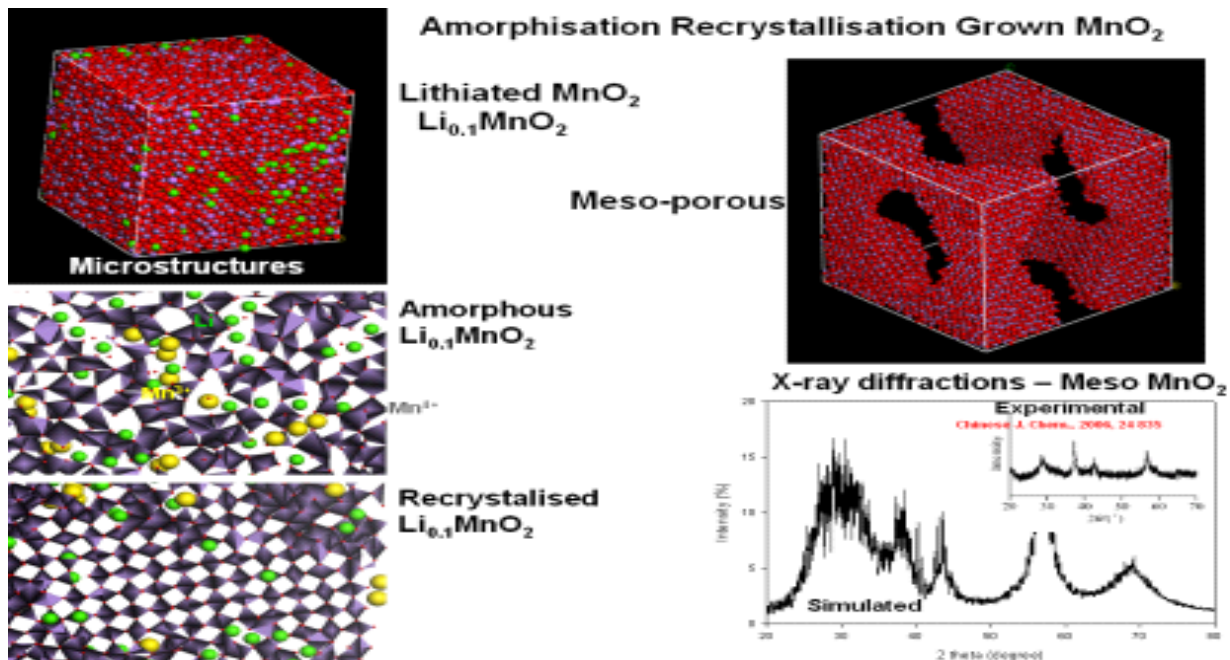
*2024)*

*\*Active refers to at least 1000 compute hours used over the relevant period.*

| Company             | #Hours<br>(Millions)<br>(All Time) | %    |  | Company                     | #Hours<br>(Millions)<br>(All Time) | %            |
|---------------------|------------------------------------|------|--|-----------------------------|------------------------------------|--------------|
| Johnson Matthey     | 5923194                            | 46.0 |  | Ex Mente                    | 40489                              | 0.3          |
| eScience            | 2331554                            | 18.1 |  | Venter Consulting Engineers | 38051                              | 0.3          |
| De Beers Marine     | 897643                             | 7.0  |  | IGS                         | 34538                              | 0.3          |
| Aerotherm           | 801332                             | 6.2  |  | Structa Konsult             | 31444                              | 0.2          |
| Hatch               | 509937                             | 4.0  |  | Howden South Africa         | 26865                              | 0.2          |
| Cauchy Consult      | 431948                             | 3.4  |  | PABT                        | 23800                              | 0.2          |
| Inqaba Biotec       | 315584                             | 2.5  |  | Eskom                       | 21745                              | 0.2          |
| Epsilon Engineering | 229477                             | 1.8  |  | Cinnamon Teal Aerospace     | 19542                              | 0.2          |
| Starke Ayres        | 226635                             | 1.8  |  | Zutari                      | 17957                              | 0.1          |
| Qfinsoft            | 175820                             | 1.4  |  | Multotec                    | 17463                              | 0.1          |
| BBE Consulting      | 168401                             | 1.3  |  | FTT Technology, Namibia     | 13383                              | 0.1          |
| Zutari              | 145217                             | 1.1  |  | Biomine Health              | 10992                              | 0.1          |
| Kapa Biosystems     | 133260                             | 1.0  |  | Rotech Systems              | 8585                               | 0.1          |
| Mamadi & Company SA | 112318                             | 0.9  |  | Sebenzana Consulting        | 8101                               | 0.1          |
| Aim Technologies    | 110390                             | 0.9  |  | Knight Piv©sold Consulting  | 6946                               | 0.1          |
| Greenplan           | 86715                              | 0.7  |  | EnFloTech                   | 4296                               | 0.0          |
| SMEC                | 81803                              | 0.6  |  | EMSS Consulting             | 2453                               | 0.0          |
| GLPS                | 75071                              | 0.6  |  | Nanodyn                     | 1748                               | 0.0          |
| Agriprotein         | 70780                              | 0.6  |  | Altair Engineering Ltd      | 1351                               | 0.0          |
| Mintek              | 40648                              | 0.3  |  | <b>TOTAL</b>                | <b>13197478</b>                    | <b>100.0</b> |

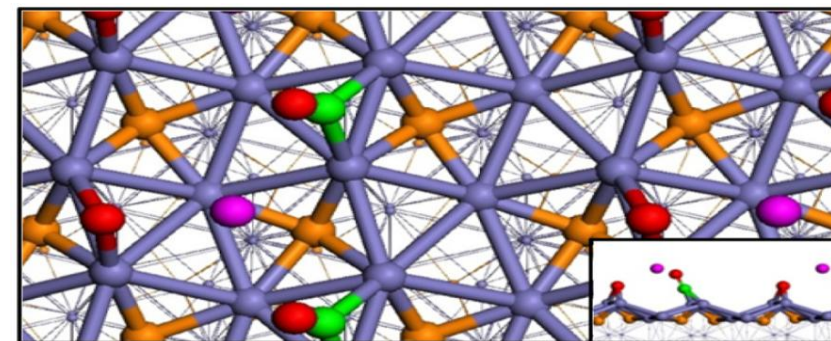
# ***HPC Applications: Materials***

## ***Materials Science / Chemistry / Health***

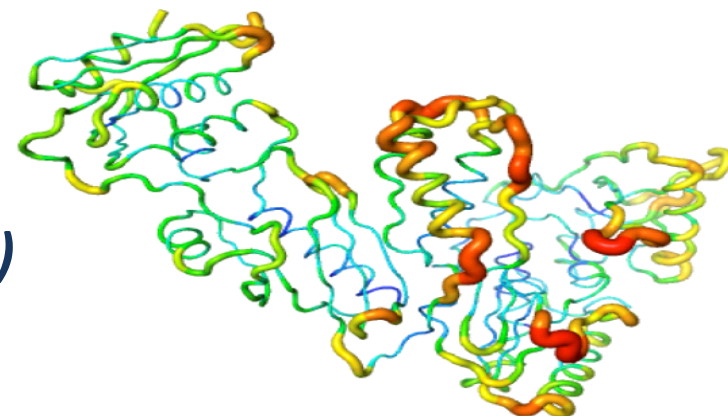


***Energy Storage – Battery  
Development  
(Materials Science)***

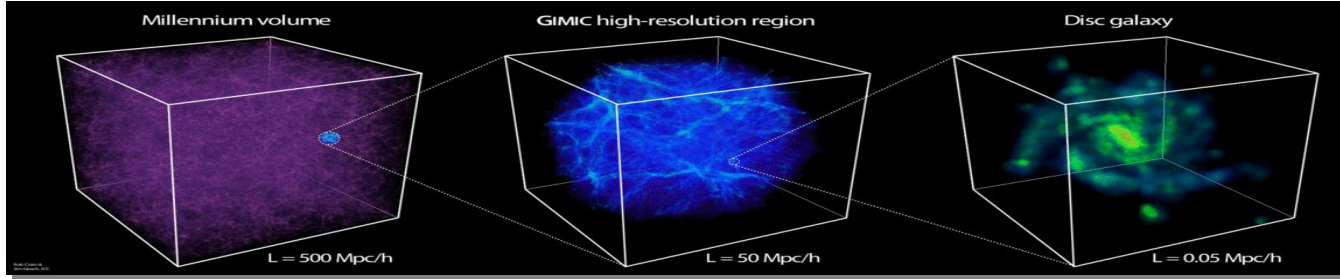
***Drug-Design Molecular  
Modelling  
(Computational Chemistry)***



***Computational Catalysis  
(Comp Chem / Materials Science)***

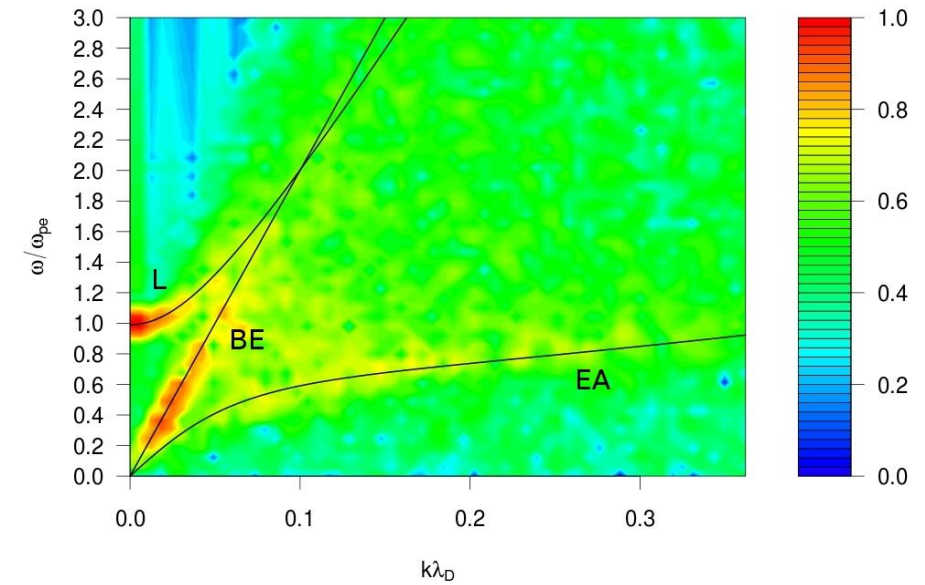
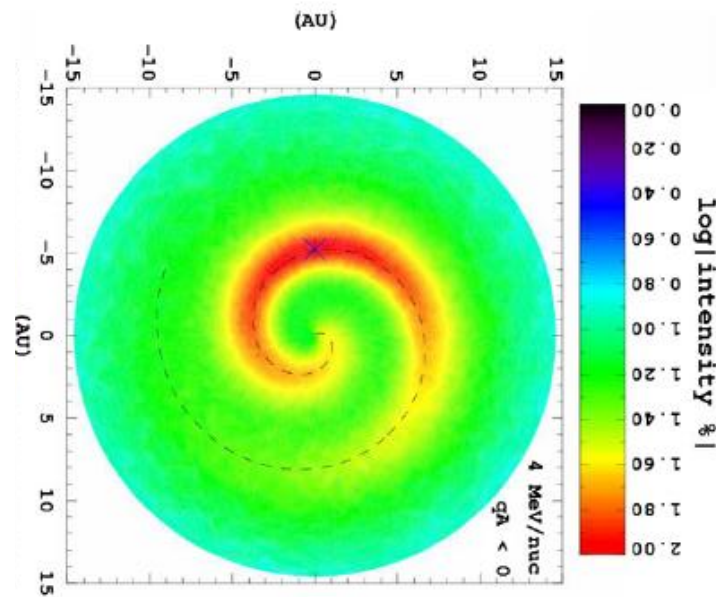


# HPC Applications: Astronomy



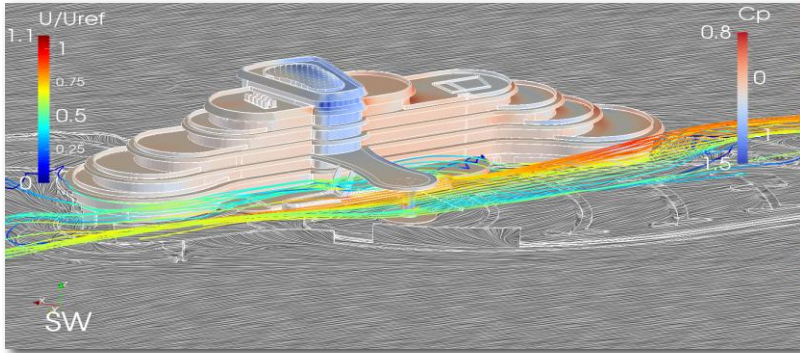
**Astronomy/Cosmology (Universe/Galaxy Evolution)**  
*(Courtesy Cress and Cunnama)*

**Electron intensities –  
Jupiter rel to Sun (NWU)**

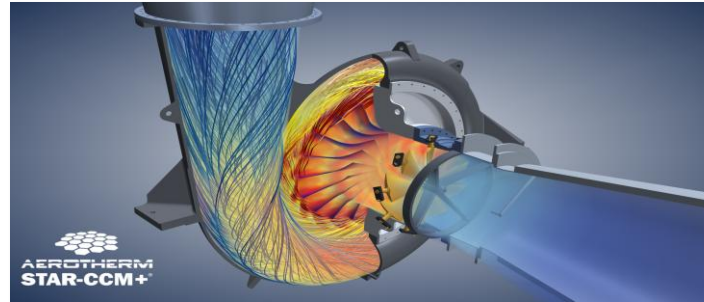


# HPC Applications: Engineering

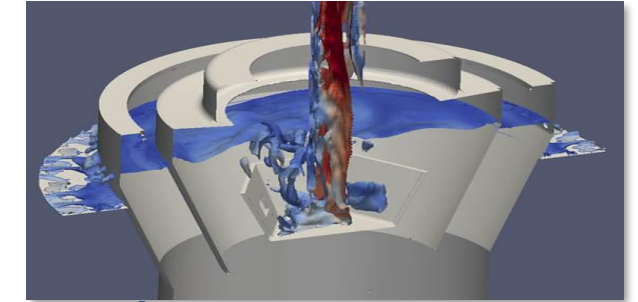
## Computational Mechanics / Engineering



**Building aerodynamics**  
**(ECI-JV)**

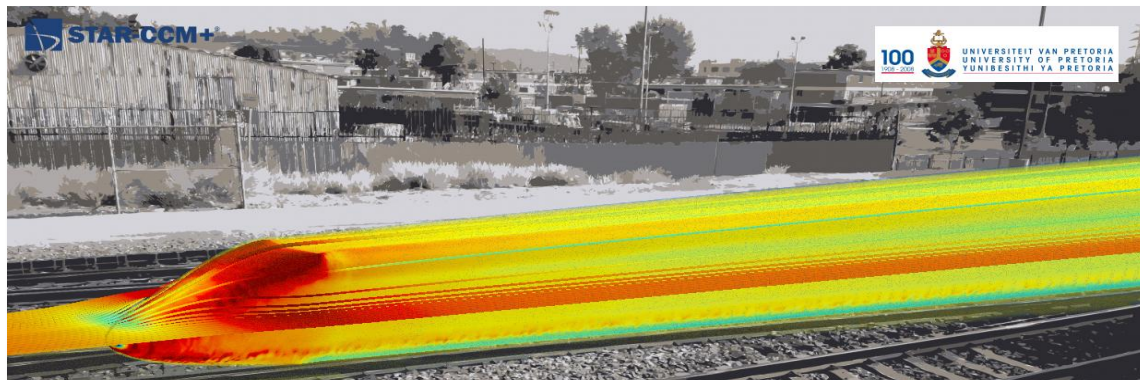


**Centrifugal Steam Compressor**  
**(Aerotherm)**

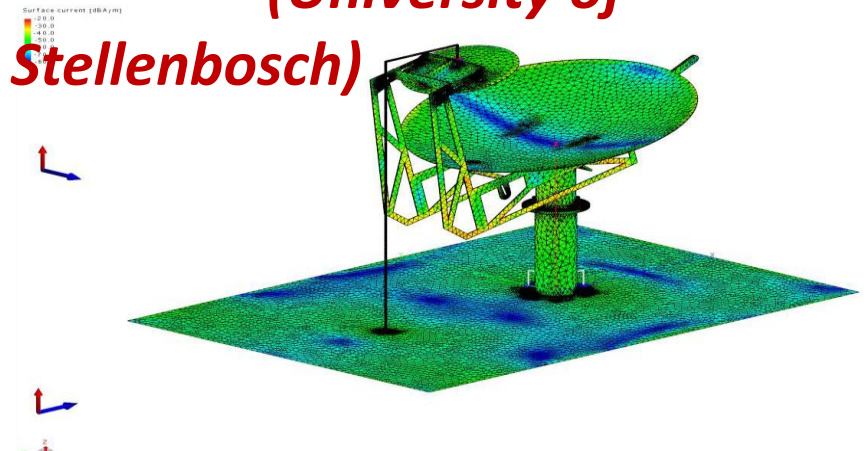


**Elutriator Design**  
**(De Beers Marine)**

**High-speed Train Design (UP):**



**Radio-Astronomy Dish Design**  
**(University of Stellenbosch)**



# HPC Applications: Earth Sciences

## CASE STUDY

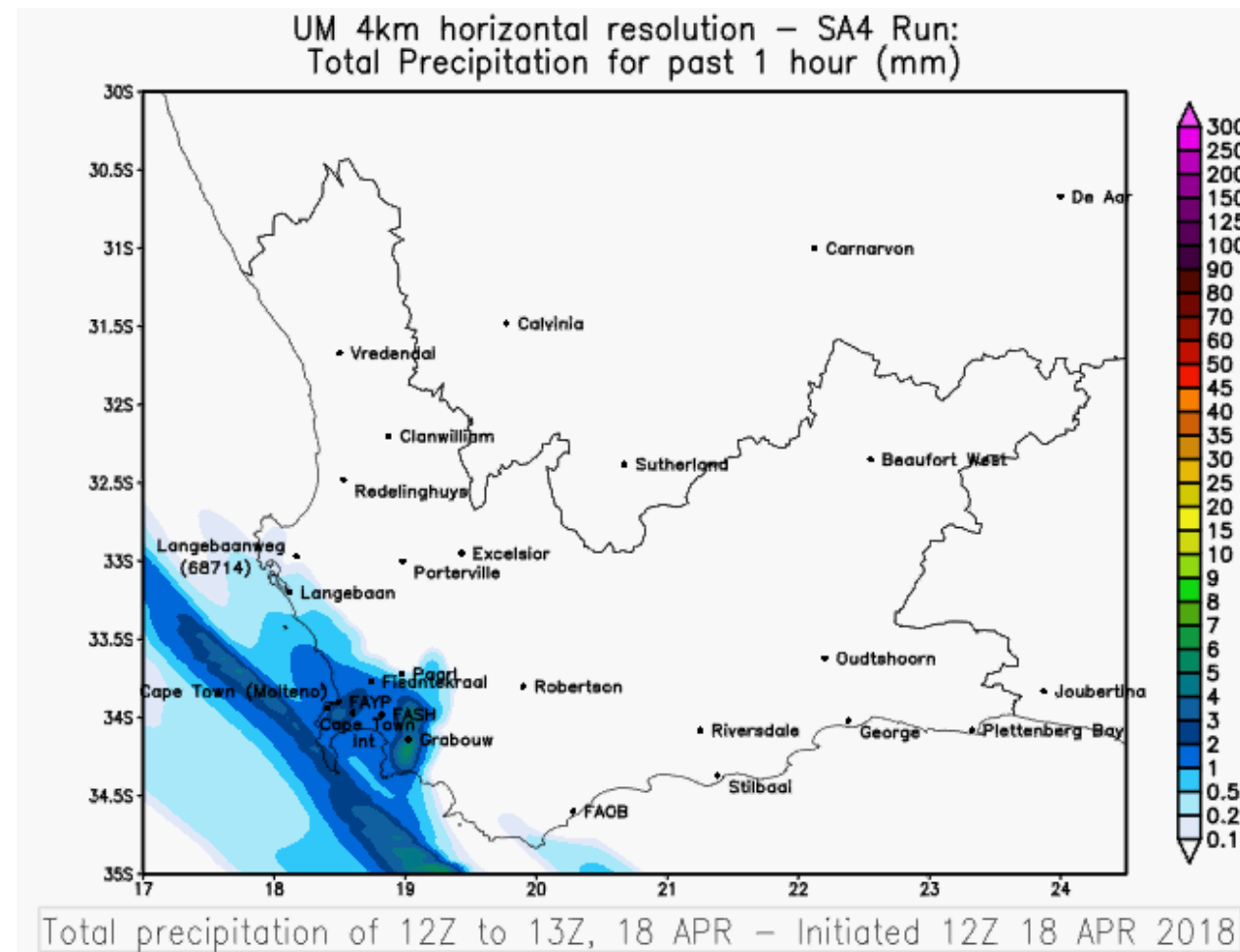
## Weather Prediction

South African Weather Service (SAWS)

CHPC-SAWS MoU:

❑ CHPC is *Fail-Over Facility*

❑ All *SAWS Research* done at CHPC



1st UM forecast which ran operationally on the CHPC in April 2018 (Dr S Landman)

# Mvula / LapAI-Forecast — project status

Code for Earth · African Stream · dual close-out: AF t2m skill + laptop demo (→ 23 Sep 2026)



**Mvula** — Compressing ECMWF's AIFS for Edge Deployment.

Code for Earth 2026 · African Stream · freeze v5: analysis-forced African t2m · ~8.8 MiB student · CPU inference.

Freeze v5 as the Code for Earth student artefact: analysis-forced t2m skill vs K1, plus CPU size/speed evidence. No free-running 10-day claim from Cout=3.

Phase 0 / Track A

Student

Cache gate

AF t2m campaign

Laptop CPU

Done

v5 freeze

2/3

Ready

8.8 MiB

↑ K1 teacher accepted

↑ 65→3 · Case A

↑ tp soft-fail

↑ expanded JSON

↑ ~2.5s/step

Mvula matrix Track B skill Laptop demo Track A overview Track A figures Spatial maps Pipelines IC regridding 2024–2025 split A1 gate Checklist

## Spatial patterns — ERA5 vs AIFS teacher vs coarsened output

Africa eval grid (0.25°) · Phase 0 NetCDF = N320 AIFS teacher · Track A NetCDF = coarsened O96 smoke run · ERA5 from GCS (needs ADC login)

Init date

Lead (h)

Variable

✓ Include ERA5 (GCS) ?

< Manage app

### Reports

OK FINAL\_REPORT.md

OK

MVULA\_CODE4EARTH\_STATUS\_MATRIX.md

OK MVULA\_LAPTOP\_BENCHMARK.json

OK TRACKB\_STATE\_CLOSURE.md

OK TRACKB\_GATE\_V5.json

OK TRACKB\_HELD\_OUT\_JAN2023\_V5.json

OK TRACKB\_T2M\_EXPANDED.json

OK TRACKA\_A1\_GATE.json

OK TRACKA\_COARSEN\_SCORECARD.json

OK PHASE0\_BASELINE\_SCORECARD.json

# ***Practical Offerings from the CHPC***

- ❑ Significant HPC **hardware resources**
- ❑ **In-house expertise** to facilitate commercial M&S/HPC activities
  - ❑ *Provisioning of installed & tested **software systems***
  - ❑ *Expertise in **open source tools***
  - ❑ **Domain specific expertise** (*in-house application scientists*)
  - ❑ **Practical support:** *licensing, data transfer, job scripts, remote visualisation, problem solving, workflow development, etc.*
  - ❑ **Off-site license communications** *set-up (via SSH tunnels)*
  - ❑ *Advice on **M&S strategies** to be pursued*
  - ❑ **Co-negotiation** *with commercial software vendors*

# ***CHPC Student Cluster Competition (SCC)***

## ***International SCC Competition (Germany)***



2013 - 1<sup>st</sup> Place



2014 - 1<sup>st</sup> Place



2015 - 2<sup>nd</sup> Place



2016 - 1<sup>st</sup> Place



2017 - 2<sup>nd</sup> Place



2018 - 3<sup>rd</sup> Place



2019 - 1<sup>st</sup> Place

2020 – 2023 Participated in Virtual Competitions...



# Conclusion

- Research software is not an HPC issue. HPC simply makes the issue particularly visible.
- South Africa has built the machines. Now we need to deliberately build the computational capabilities around them.



# THANK YOU

AN INITIATIVE OF



MANAGED BY

