The ESA Virtual Space Weather Modelling Centre

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FNRS Contact Group, Brussels, 14 June 2019

EUHFORIA

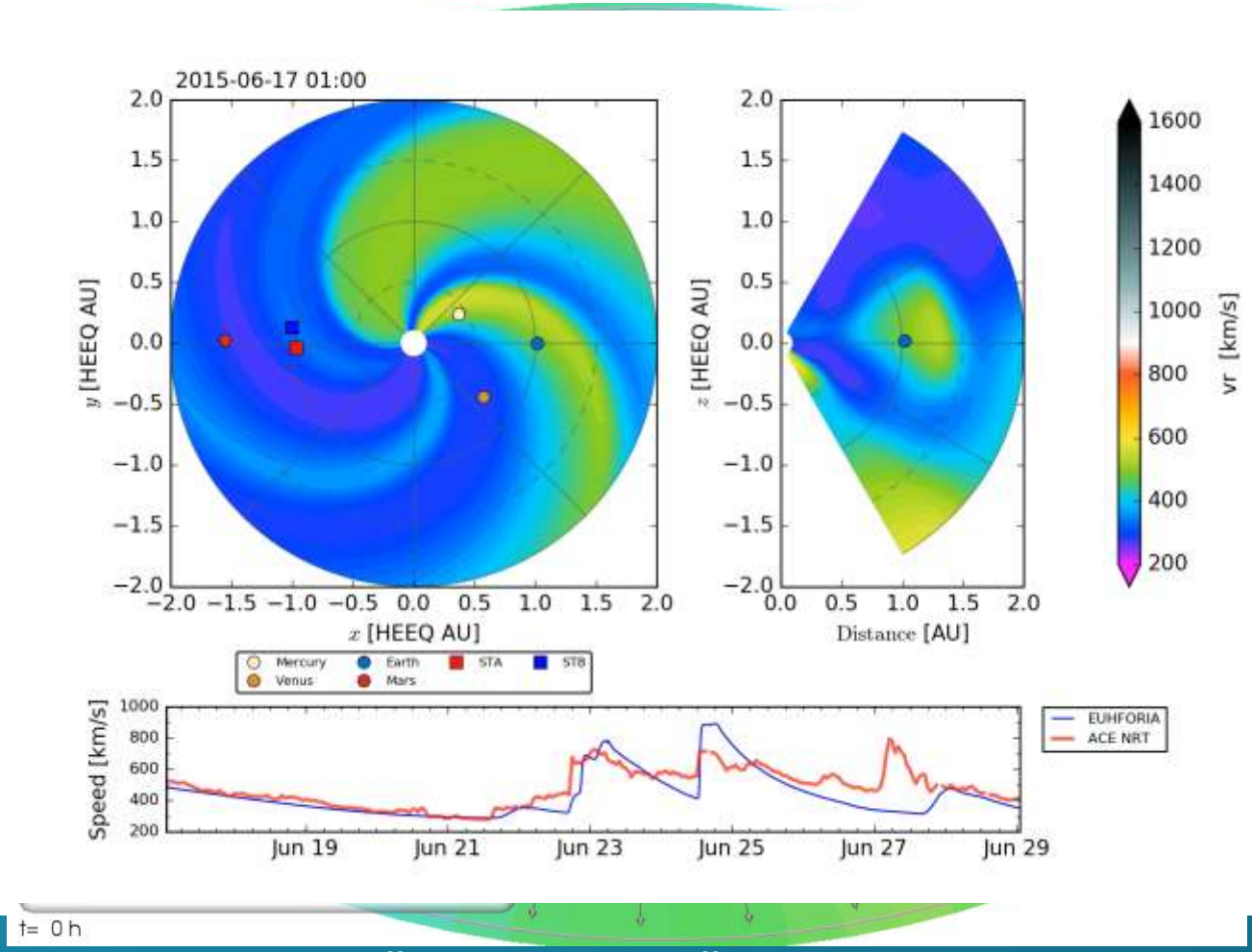
‘European heliospheric forecasting information asset’

Taking coronal model as lower boundary condition

Solar wind at @ 0.1 A
- Semi-empirical:
  - Gong/ADAPT magne
  - PFSS
  - WSA/DCHB+CSC

CMEs at @ 0.1 AU
- Cone model
- Spheromak + GL

Inner Heliosphere
- 0.1 AU → 2.1 AU
- Time-dependent 3D MHD (FVM + CT approach for advancing **B** div-free)



Credit: Jens Pomoell

EUHFORIA Rationale

Science *(CCSOM project)*:

- Quantify the deformation, deflection and erosion of **flux ropes** evolving in the inner heliosphere
- Characterize the magnetosheaths of CMEs
- Clarify the role of CME-CME interactions in enhanced SEP production

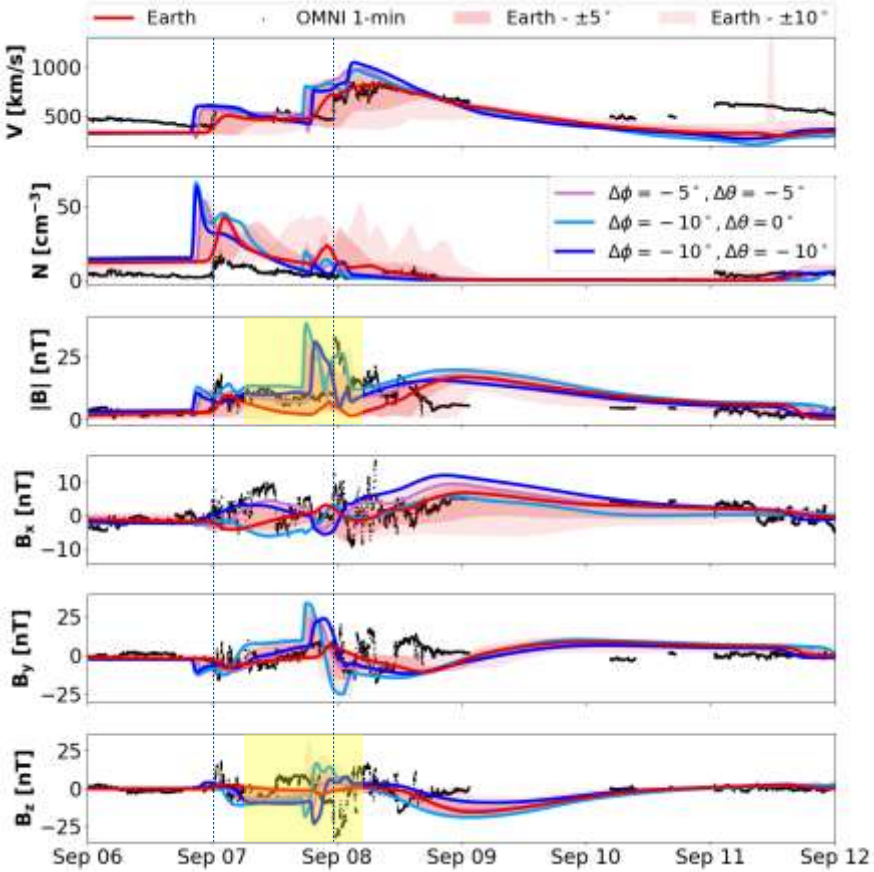
Applications:

- Space weather forecasts *("European ENLIL")*
  - Time of arrival / *Geo-effectiveness*
- Support for space missions (e.g. PSP, SolO)

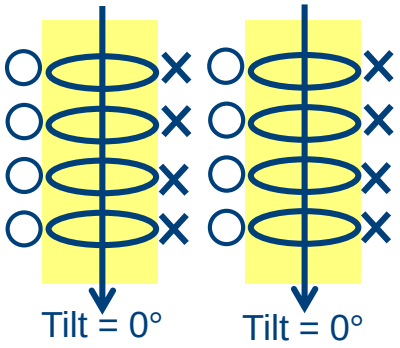
Credit: Jens Pomoell

September 2017 CMEs with EUHFORIA

Spheromak results: interacting flux-ropes



- 2 spheromaks (CMEs on Sep 4 & Sep 6)
- Flux-rope orientations:



Array of virtual spacecraft **around Earth:**

- Enhanced shock-sheath B(B_z) from compression of fields in preceding ejecta
- In situ predictions susceptible to location
  - Best B_z prediction SE of Earth

KU LEUVEN

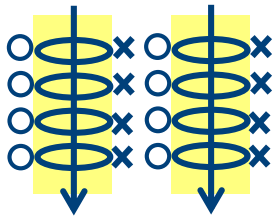
Credit: Camilla Scolini

September 2017 CMEs with EUHFORIA

First modelling of geoeffective shock-sheath from interaction with preceding magnetic ejecta using EUHFORIA

Flux-rope 2 (6 Sep 2017 CME)

Flux-rope 1 (4 Sep 2017 CME)



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Credit: Camilla Scolini

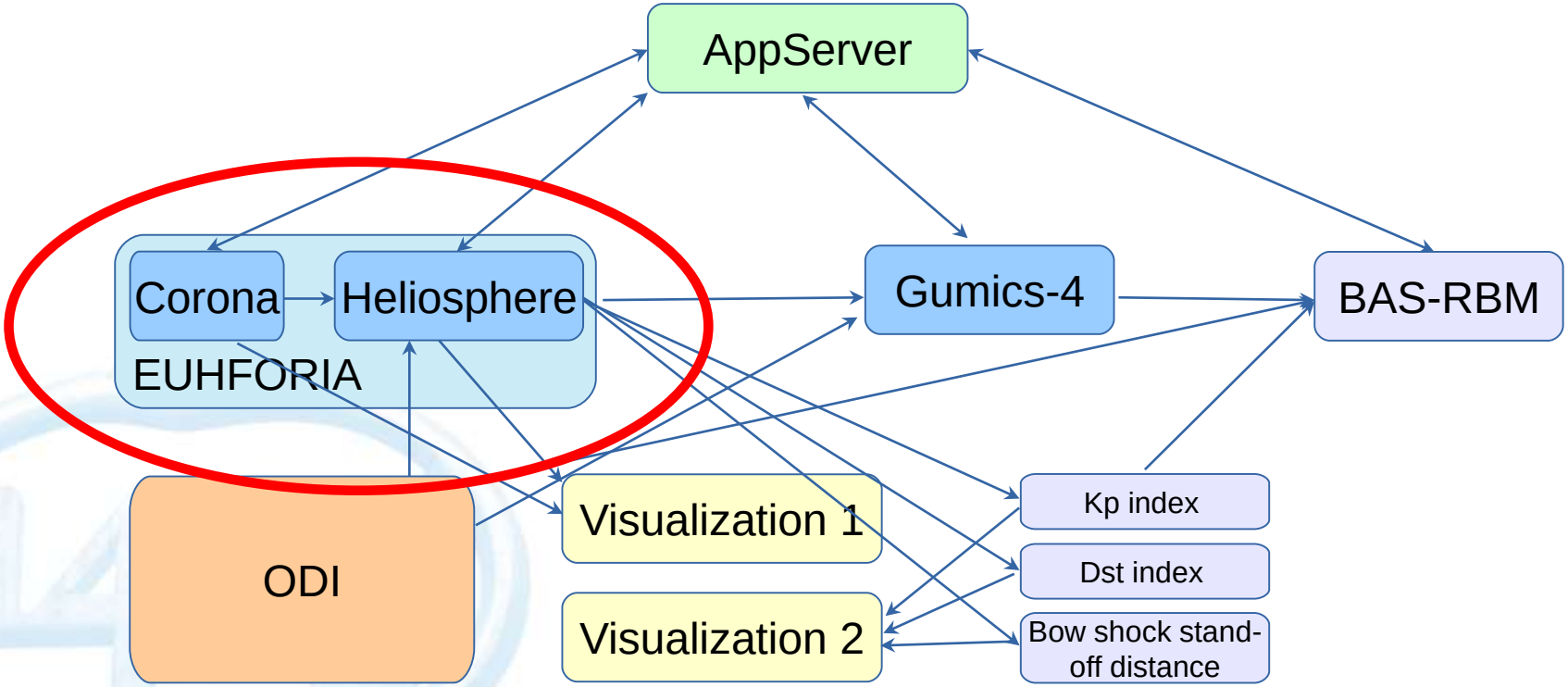
VSWMC development

- **Phase 1** *(ESTEC/Contract No. 4000106155-VSWMC – Phase 1)*
  - Study **User and System Requirements** with 5–10 yr horizon
  - Development **proof of concept prototype** (limited # models)

- **Phase 2** *(P2-SWE-XIV - Virtual Space Weather Modelling Centre - Part 2)*
  - Integration of **new models** and **new model couplings**, including a first demonstration of an **end-to-end simulation capability** + models can be installed centrally or remotely
  - Further development of the **coupling toolkit** and **front-end GUI** (available through the ESA SSA/SWE portal (28/05/19)
  - Development of *APIs &* Improved access to input and output data (SPASE format)
  - Development of **integrated visualization tool** modules

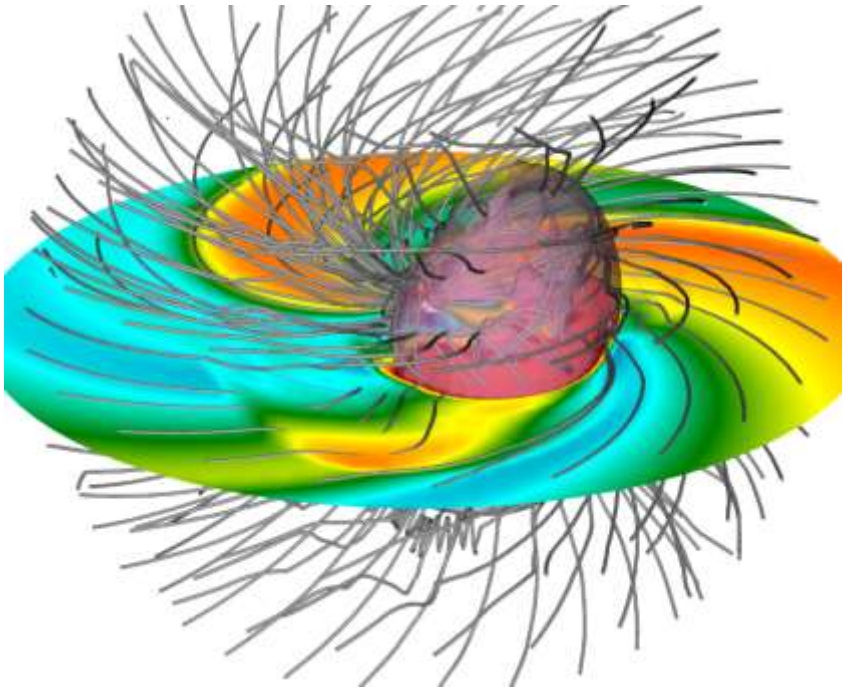
First operational version VSWMC

Framework node communication



LINK to operational system

Thank you!



Papers:

EUHFORIA + Cone CMEs:

- *Pomoell & Poedts, JSWSC, 2018*
- *Scolini et al., Space Weather, 2018*

EUHFORIA + spheromak CMEs

- *Verbeke et al., AA, 2019, in press*
- *Scolini et al., AA, 2019, in press*

EUHFORIA + SEPs

- *Wijsen et al., AA, 2019a*
- *Wijsen et al., AA, 2019b (in press)*