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Variation of Gravity Wave Activity in the Tropical UTLS A New Perspective from Aeolus Observations

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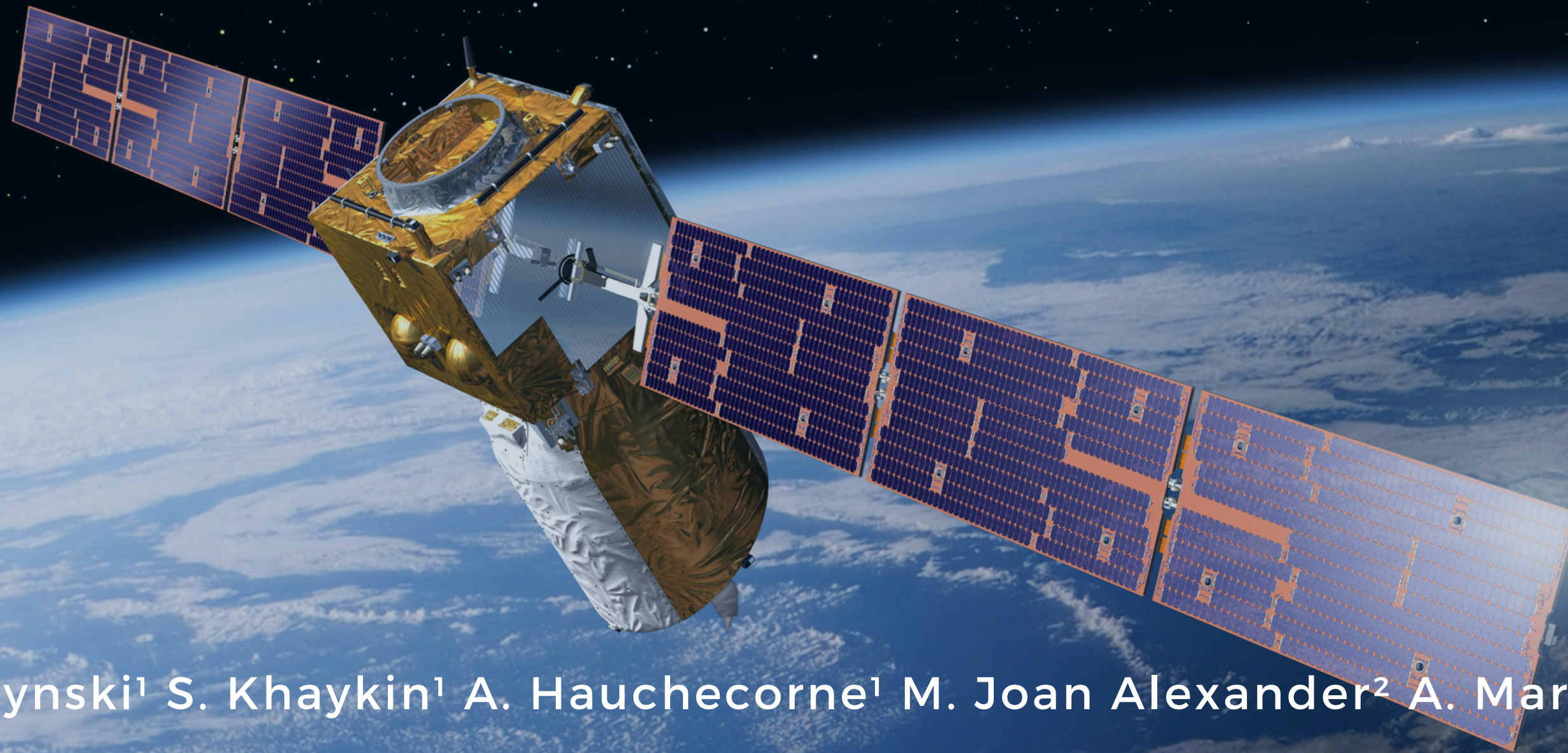
<https://insu.hal.science/insu-04601347v1>

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Variation of Gravity Wave Activity in the Tropical UTLS A New Perspective from Aeolus Observations



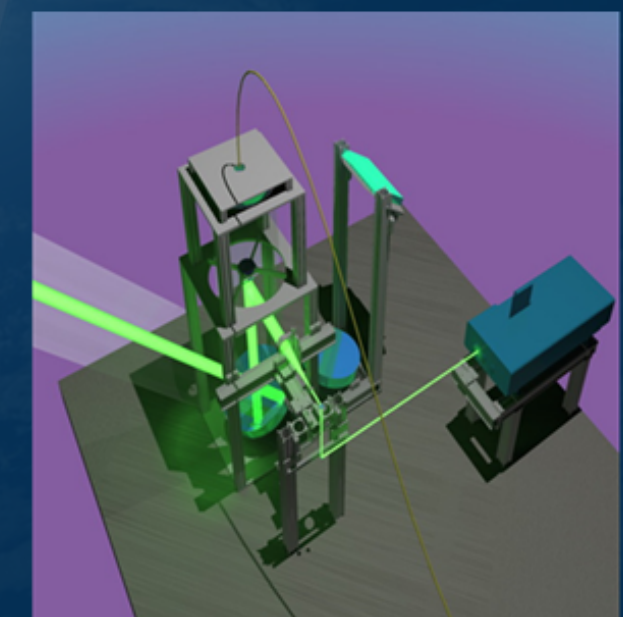
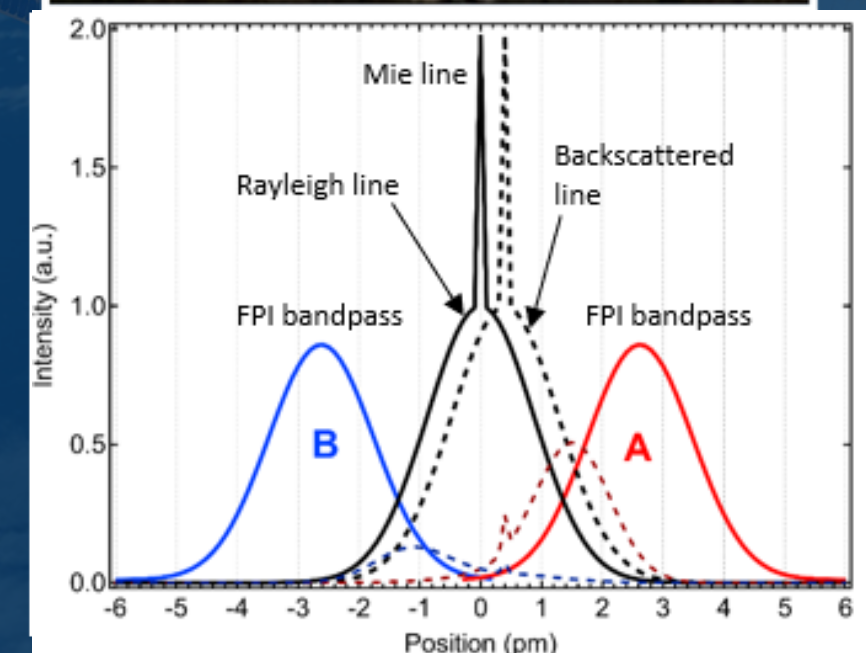
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RAYLEIGH-MIE DOPPLER LIDAR

- Doppler wind lidar at Maïdo observatory (La Reunion island)
- Doppler wind lidar at OHP observatory (Haute Provence, France)
- Double-edge Fabry-Perot interferometer: same as ALADIN Rayleigh channel
- Altitude range: 5 – 75 km, vertical resolution 100 m, temporal resolution 5 minutes, random error < 1 m/s up to 25 km altitude
- Regular operation and intensive measurement campaigns since 2014
- AboVE- Aeolus Validation Experiment: intensive measurement campaigns and punctual cal/val measurements: wind lidar and radiosoundings
- AboVE-Maido1 campaign : 25 sept 2019 to 10 oct 2019
- AboVE-Maido2 campaign : 31 may 2021 to 24 june 2021
- AboVE-OHP1 campaign : 6 Jan 2019 to 14 Jan 2019
- AboVE-OHP2 campaign : 29 nov 2021 to 13 dec 2021



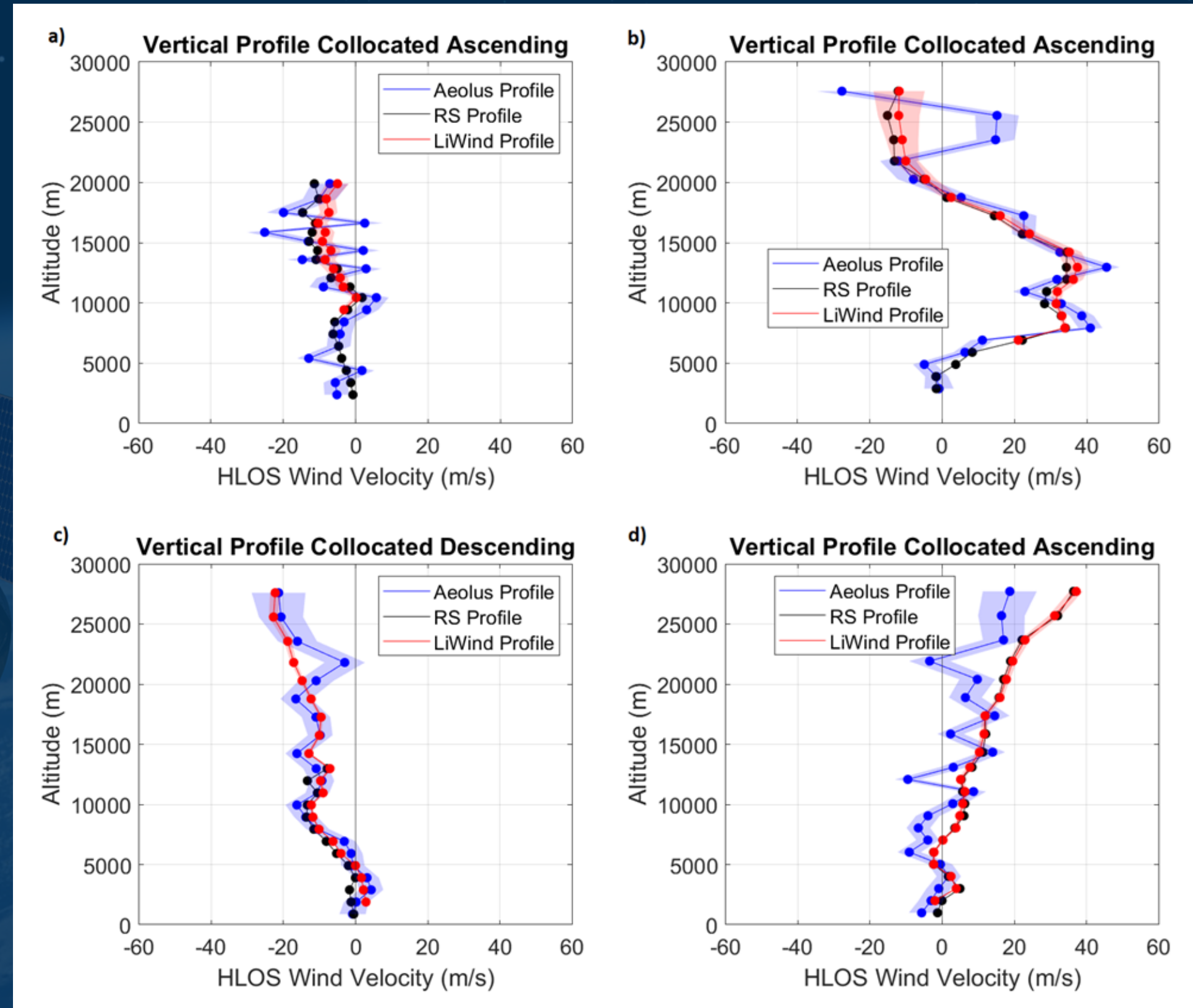
COLLOCATION CASES

a): February 24, 2021 (Above Maïdo 2) - 2B11
Oscillation only visible on satellite - I2OP ?

b): June 9, 2021 (Above Maïdo 2) - 2B12
Cone shaped pattern - High RBS flaw ?

c): 14 December 2021 (Above OHP2) - 2B13
Sudden high value - Hot pixel ?

d): December 20, 2021 (Above OHP 2) - 2B13
Oscillation + high values - Hot pixel + I2OP ?



BIAS & RANDOM ERROR

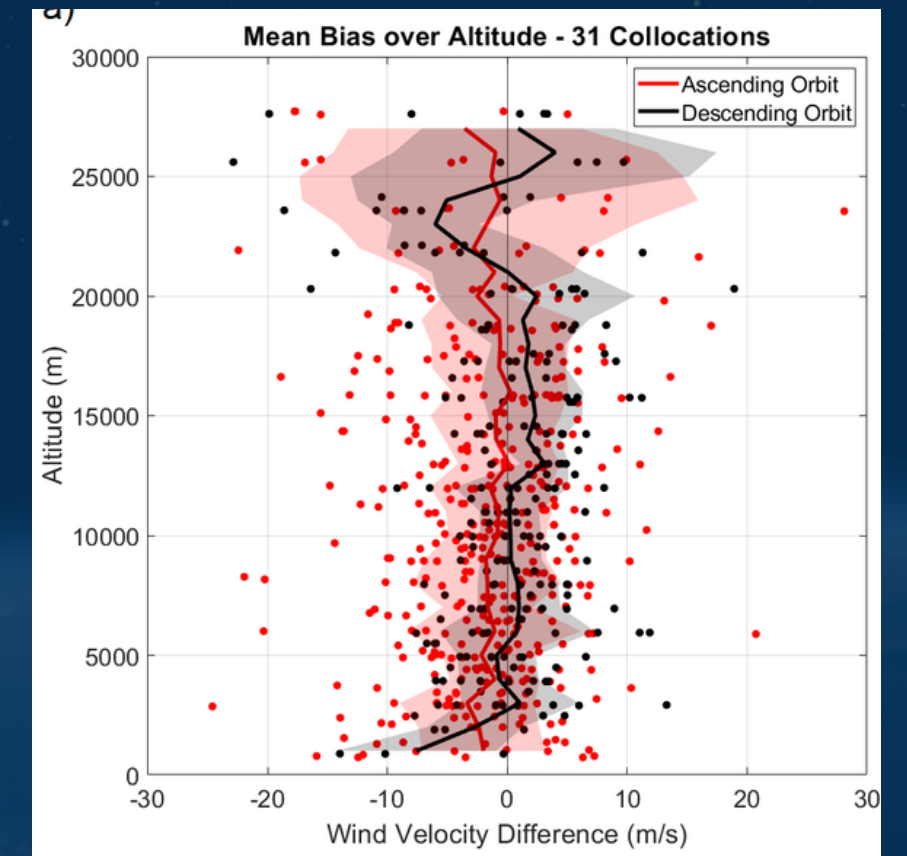
Increase of random error in the higher bins

Nominal range for comparisons is <22km

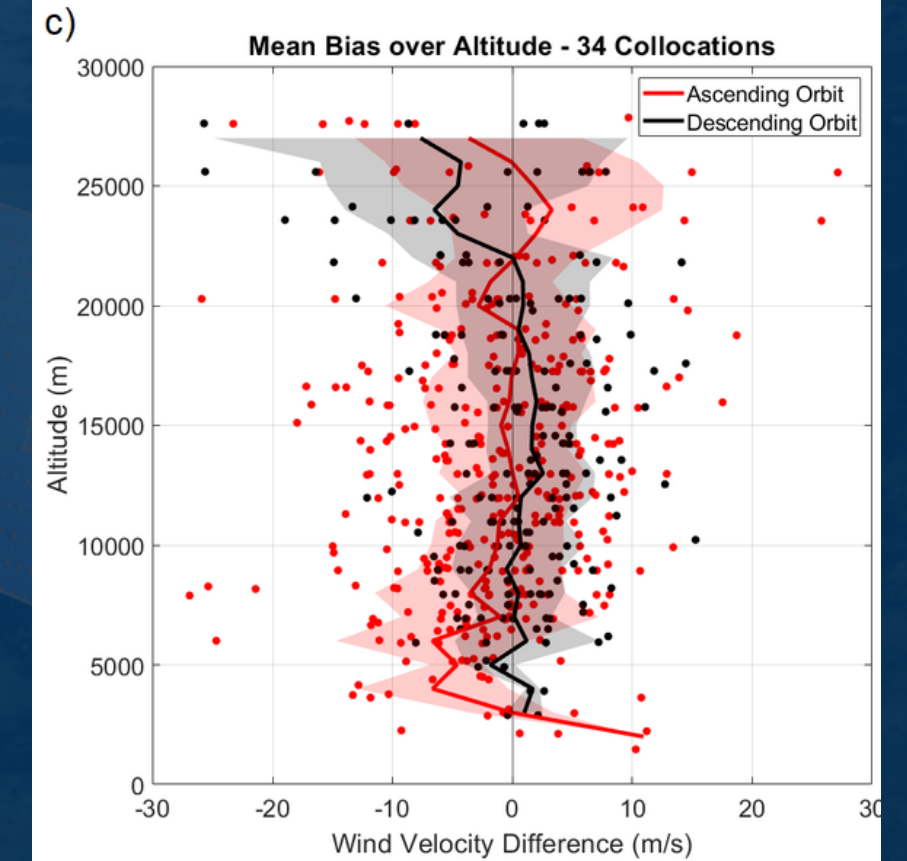
More distant collocations don't have higher biases

MISSION REQUIREMENTS

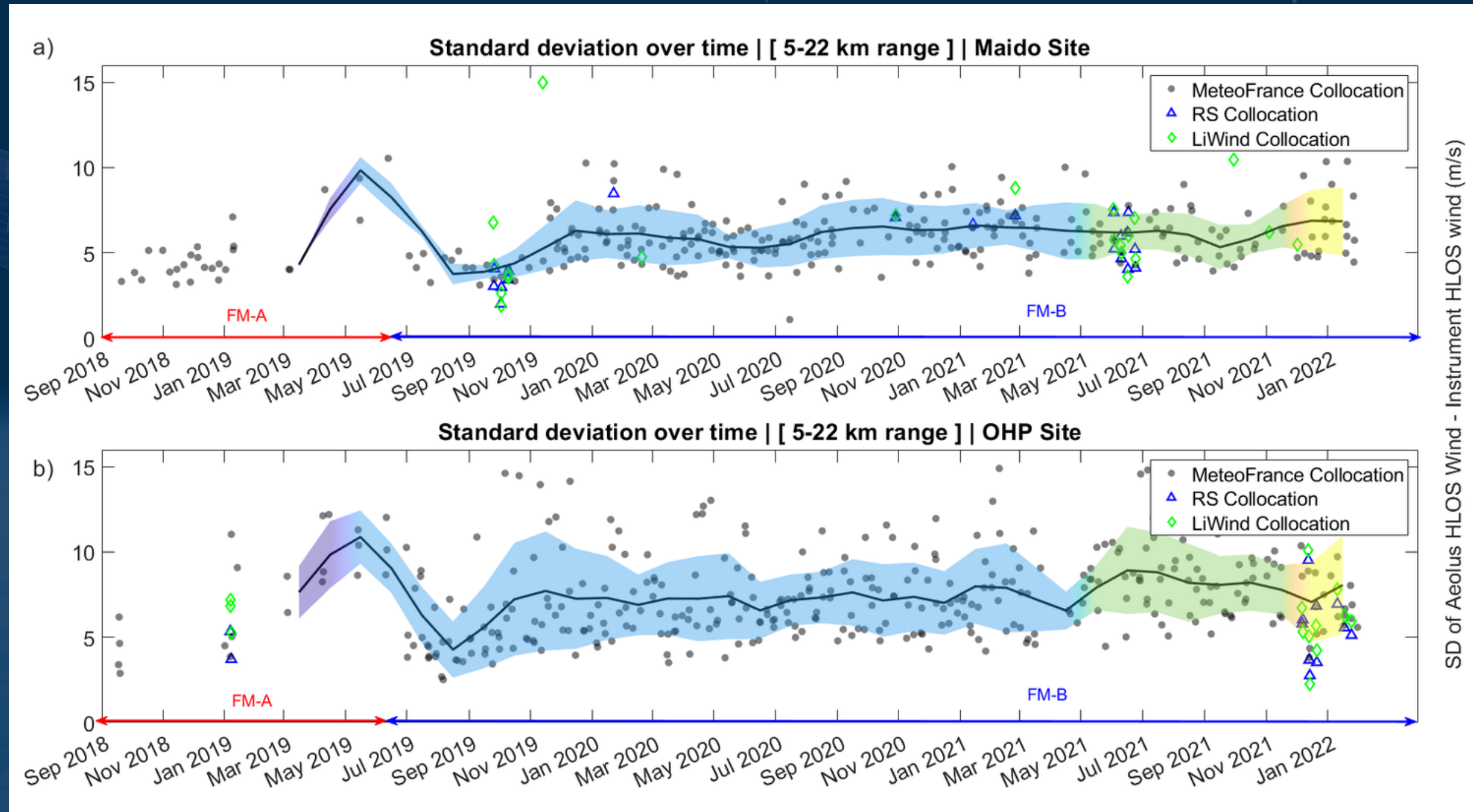
	Mission Requirement limits (ms ⁻¹)	Radiosonde (ms ⁻¹)	Lidar (ms ⁻¹)
Bias	0.7	-0.79	-0.92
SD 2-16 km	2.5	5.04	5.69
SD 16-20 km	3	4.93	5.59
SD 20-30 km	5	9.19	9.41



LIDAR



LONG TERM VALIDATION



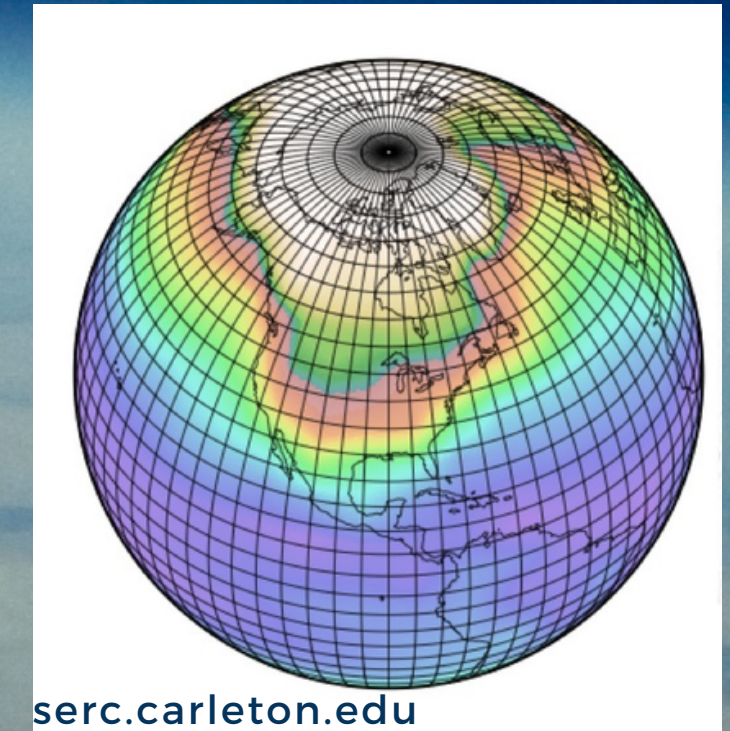
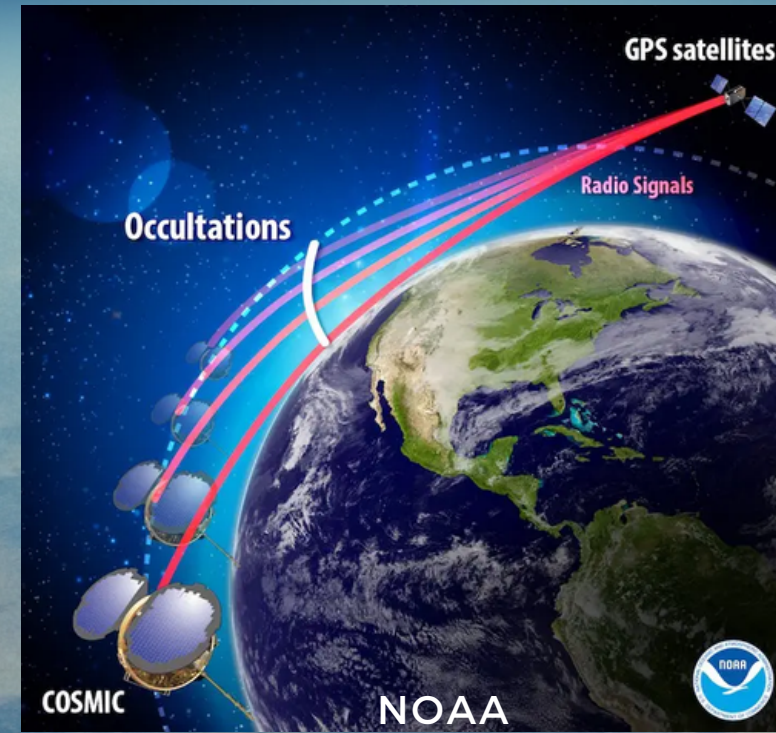
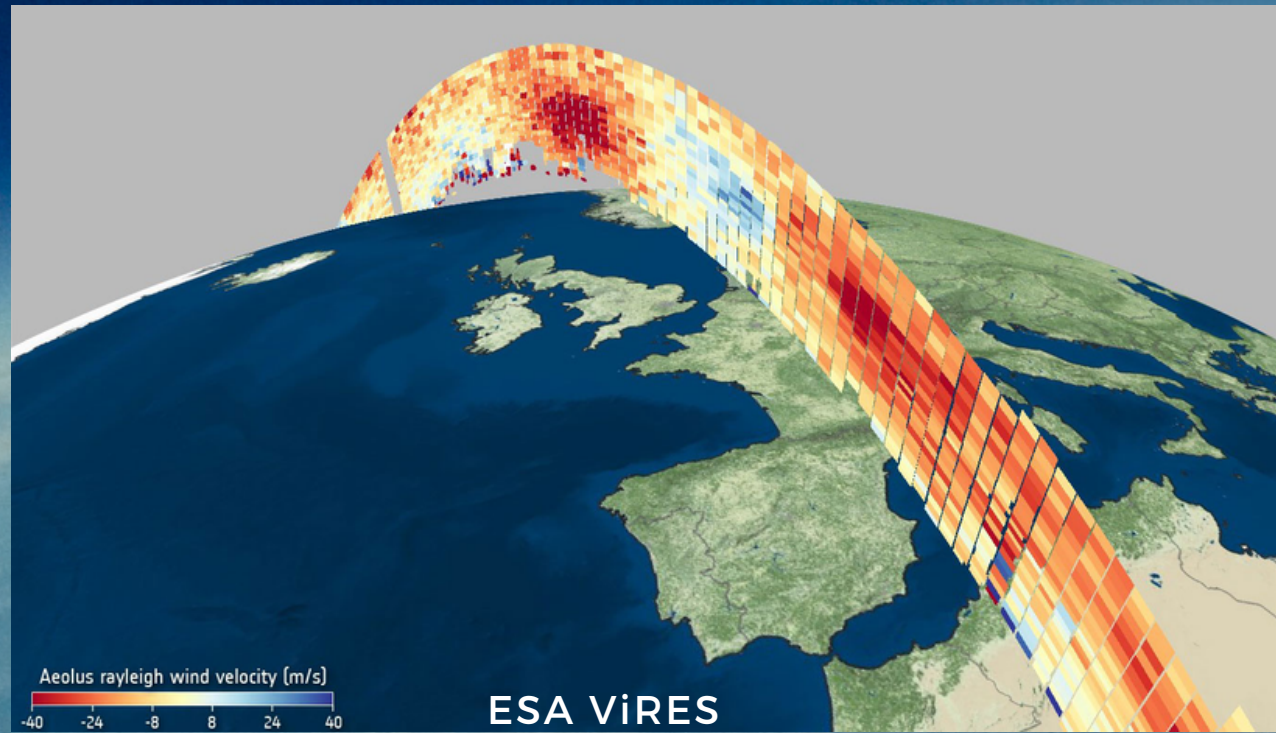
Ratynski et al., AMT 2023

Laser degradation leads to an increase in the random error

AEOLUS

GNSS-RO

ERA 5



Wind profiles

Temperature profiles

Wind & Temperature profiles

1 km Vertical Resolution

~100m Vertical Resolution

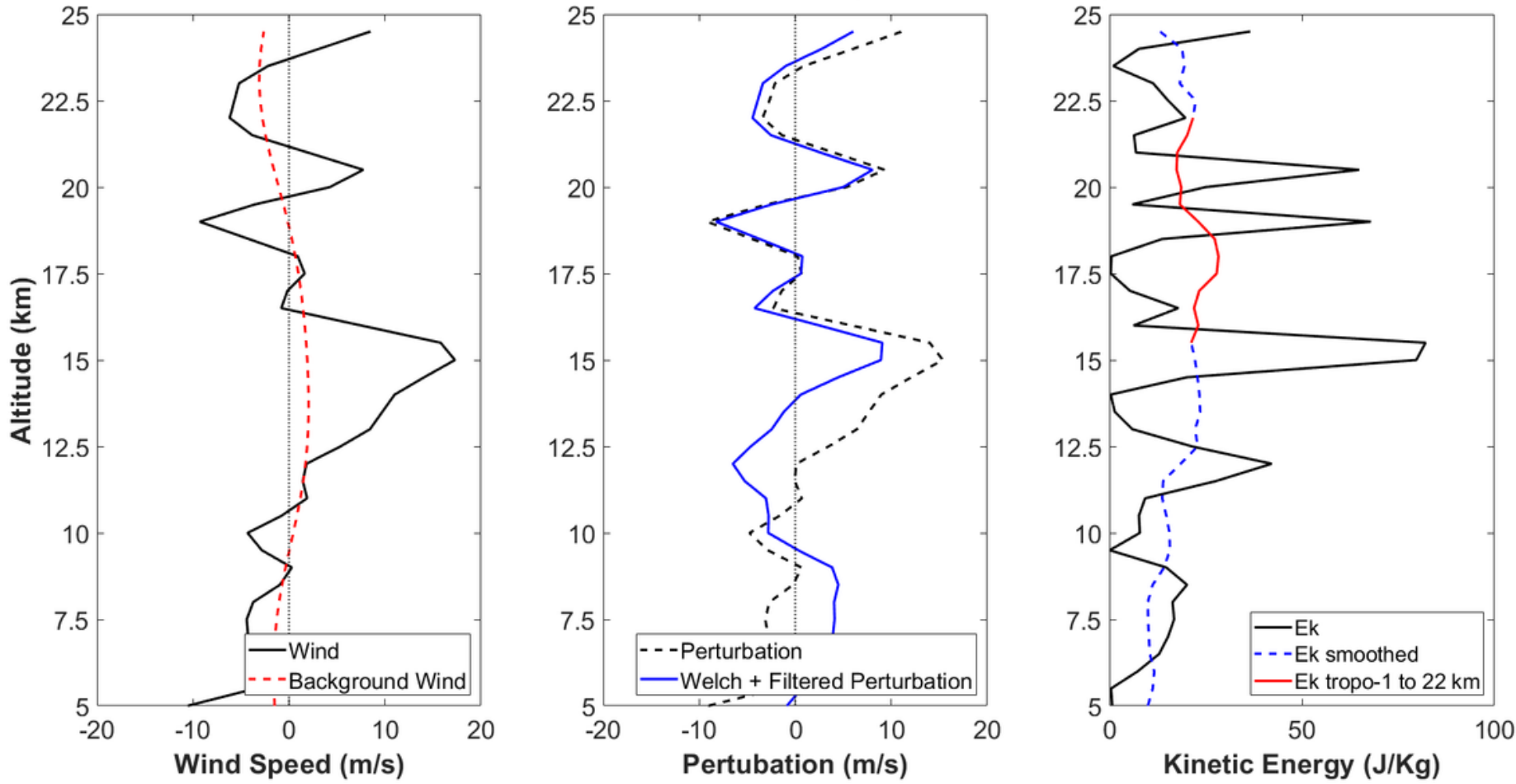
500m Vertical Resolution

Limited assimilation by ERA5

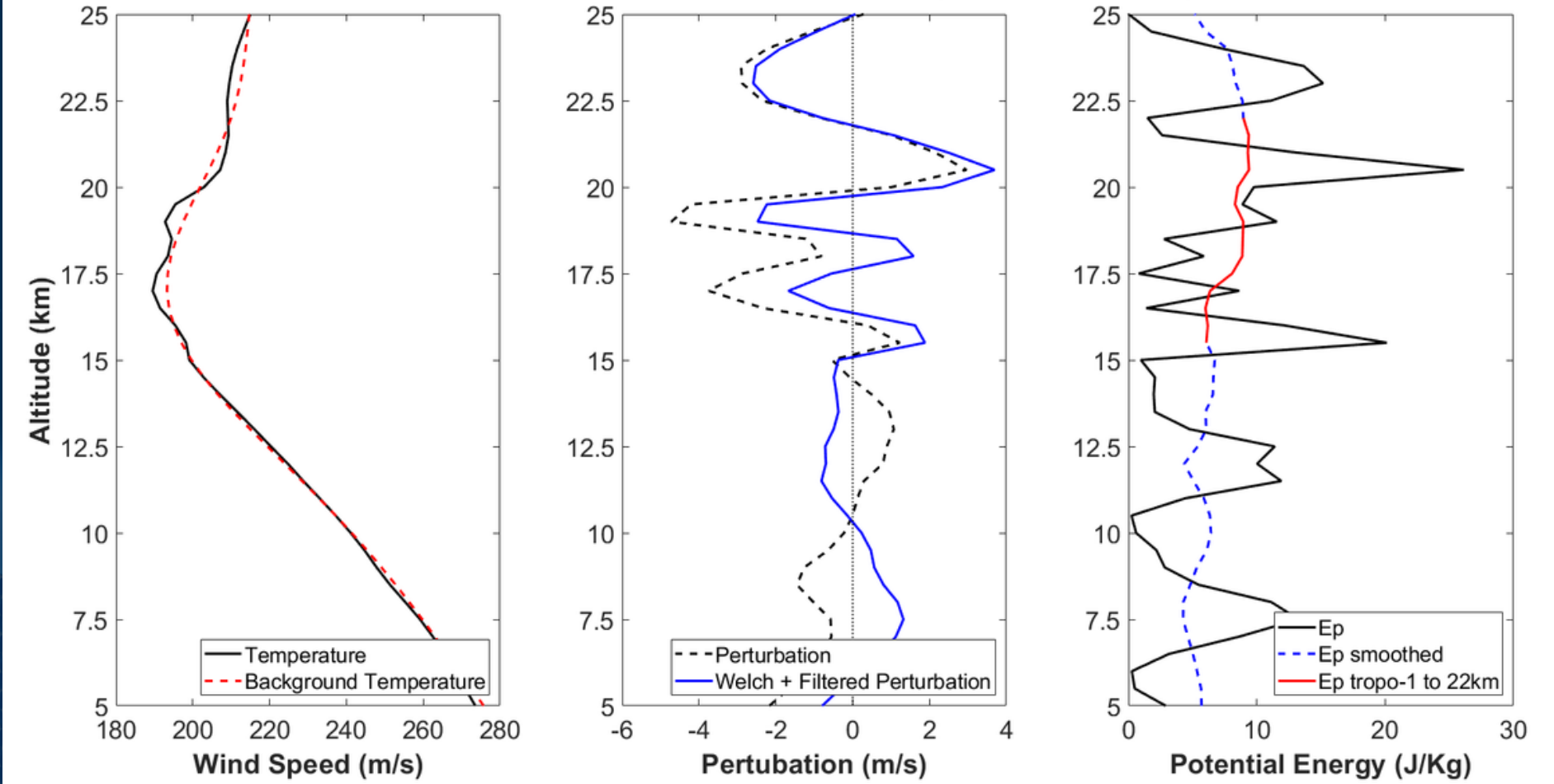
High assimilation by ERA5

Infers wind from thermal information

GW Ek retrieval method on wind profile | 4° S 102° E | 10-Feb-2021



GW Ep retrieval method on temperature profile | 4° S 102° E | 11-Feb-2021



Kinetic Energy

$$K_e = \frac{1}{2} \left[\overline{u'^2} + \overline{v'^2} \right]$$

$$K_{e\ HLOS} = \frac{1}{2} \left[\overline{U'^2_{HLOS}} \right]$$

Initial retrieval of the background
5° Lat x 20° Lon x 7 days

Filtering of the perturbation

Retrieval between 22 km and tropopause -1 km

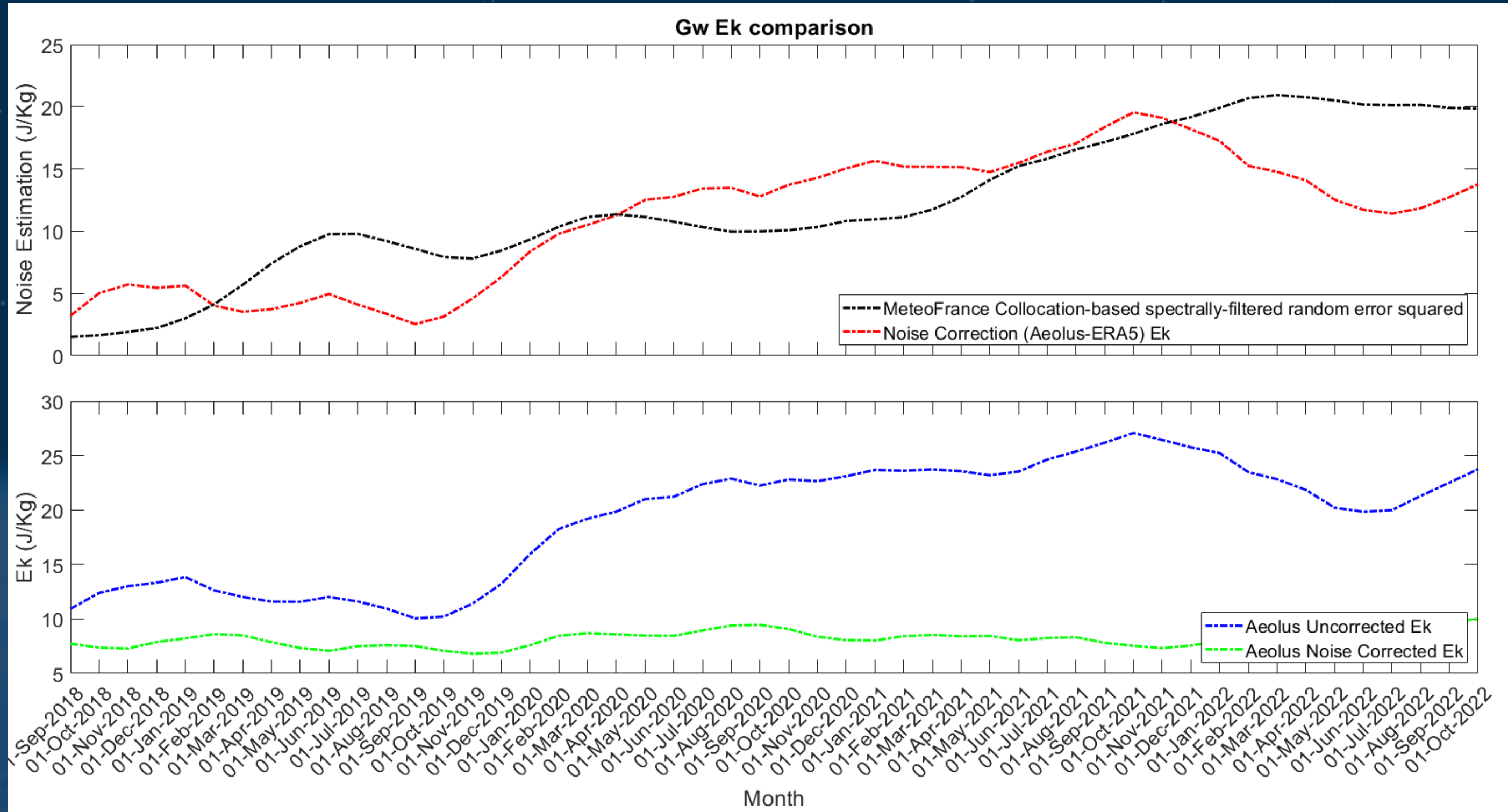
Potential Energy

$$E_p = \frac{1}{2} \left(\frac{g}{N} \right)^2 \left(\frac{T'}{\bar{T}} \right)^2$$

Filters out Kelvin and Rossby waves

HLOS involves both components at the same time

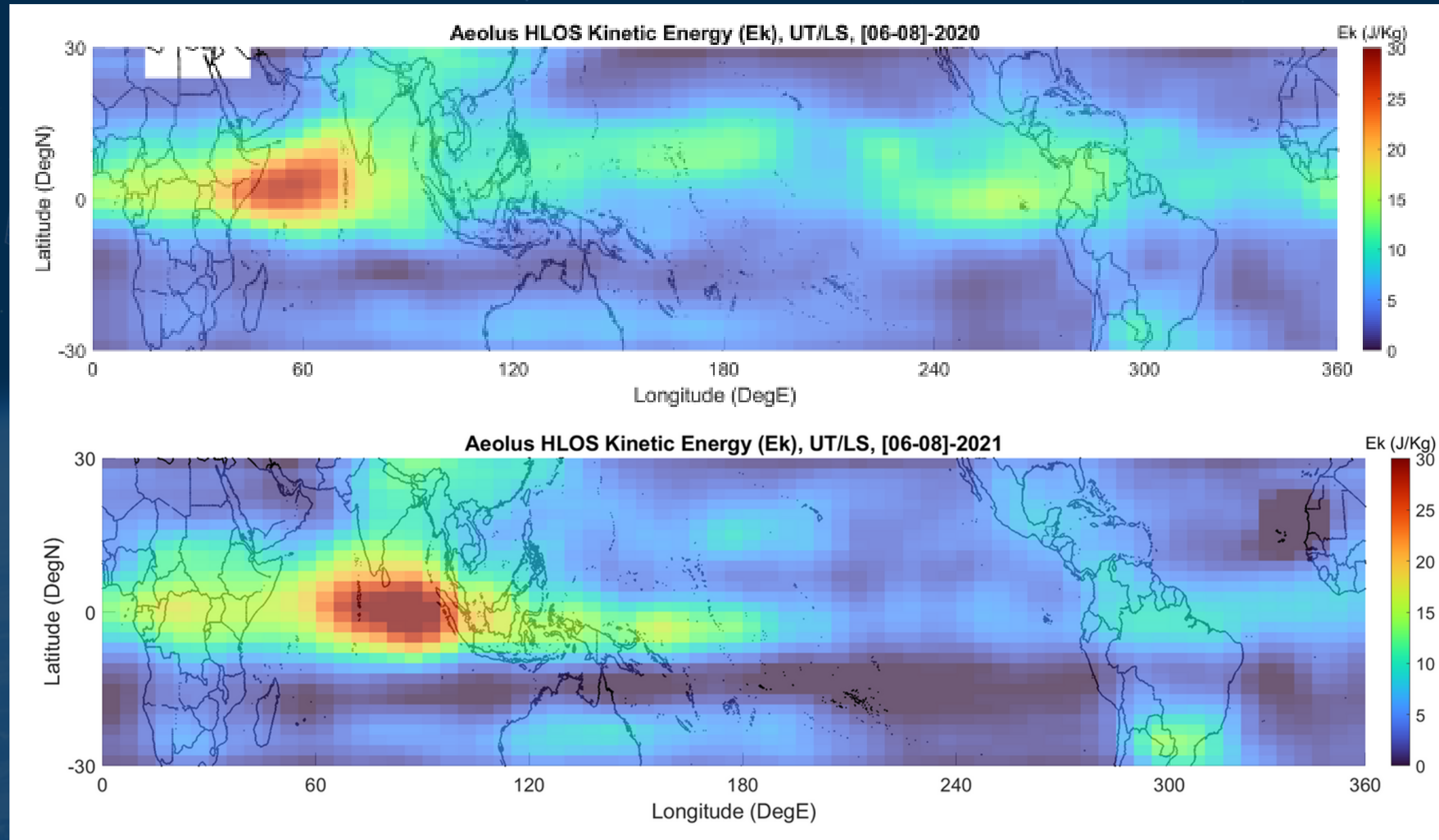
NOISE CORRECTION



Two ways of removing noise: ERA5 or Radiosondes

ERA5 is global and has less geophysical biases

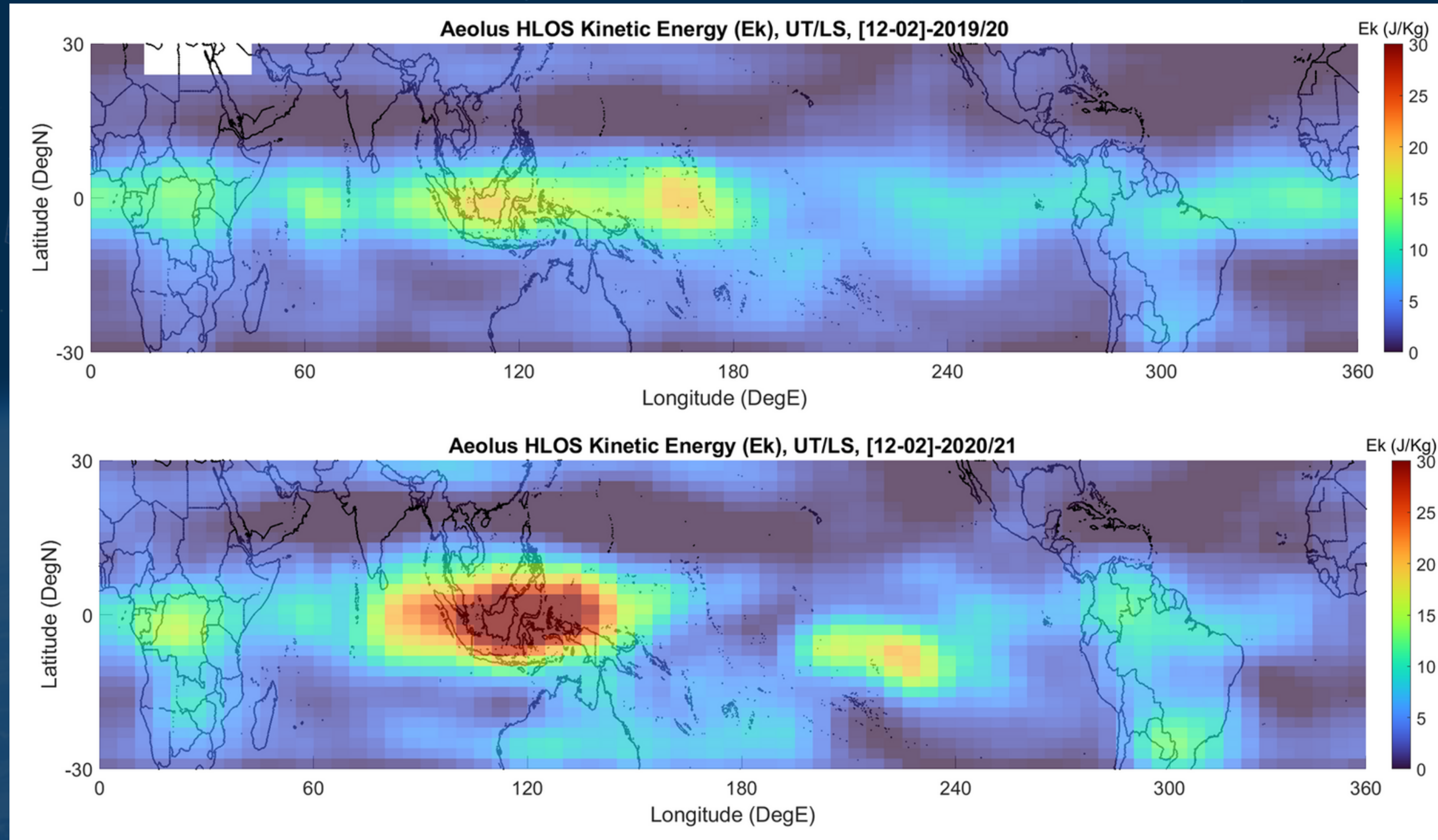
BOREAL SUMMER



Consistent structures over the same season

An axial symmetry is seen between two opposite seasons

AUSTRAL SUMMER



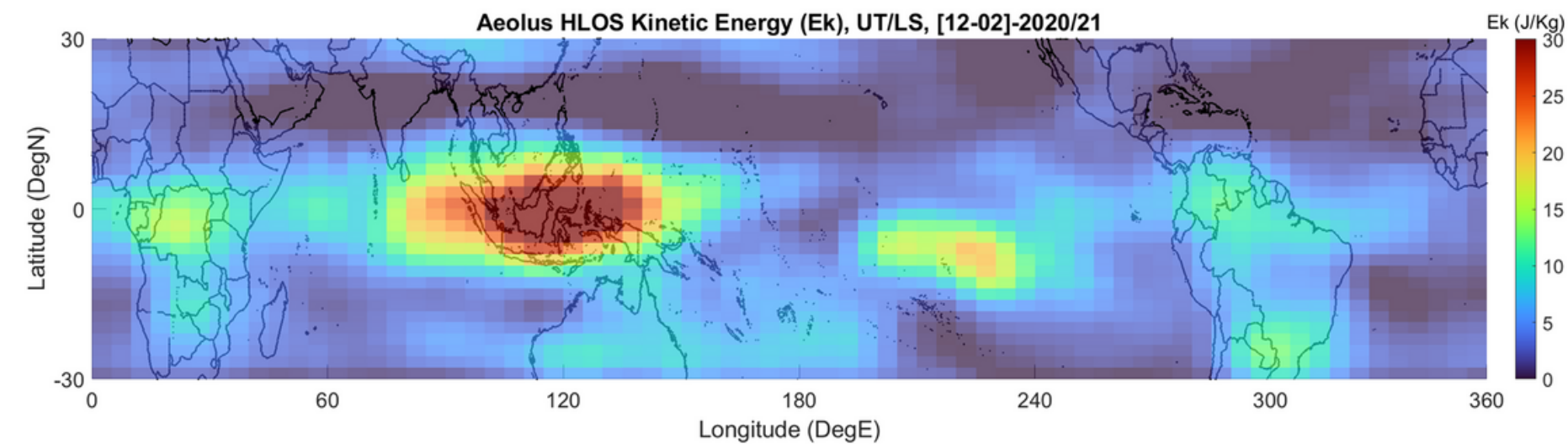
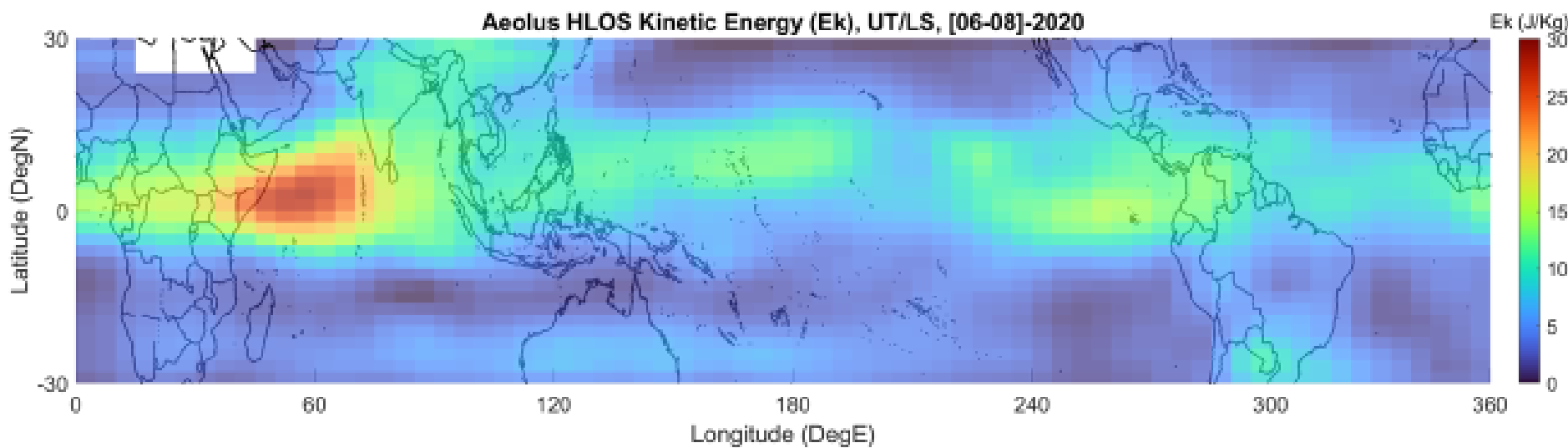
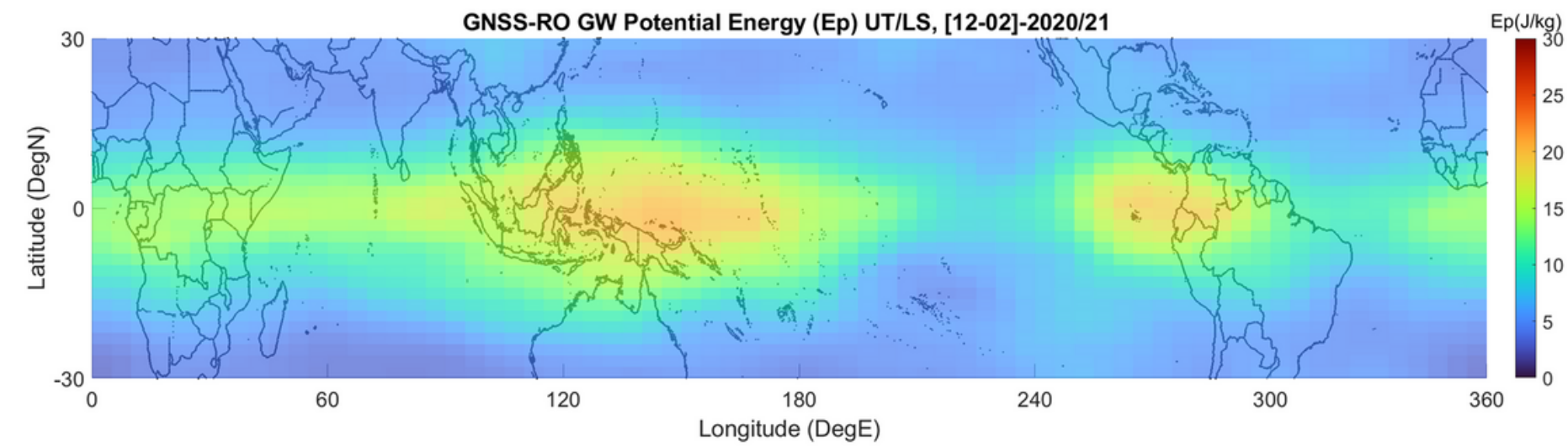
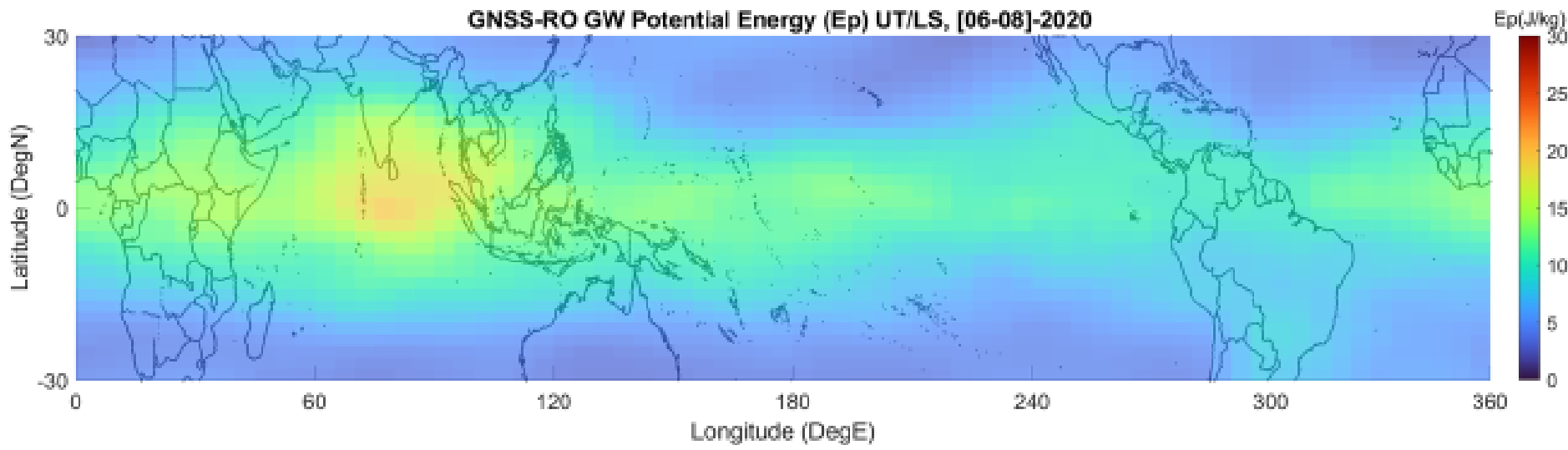
Consistent structures over the same season

An axial symmetry is seen between two opposite seasons

GNSS-RO COMPARISON

BOREAL SUMMER

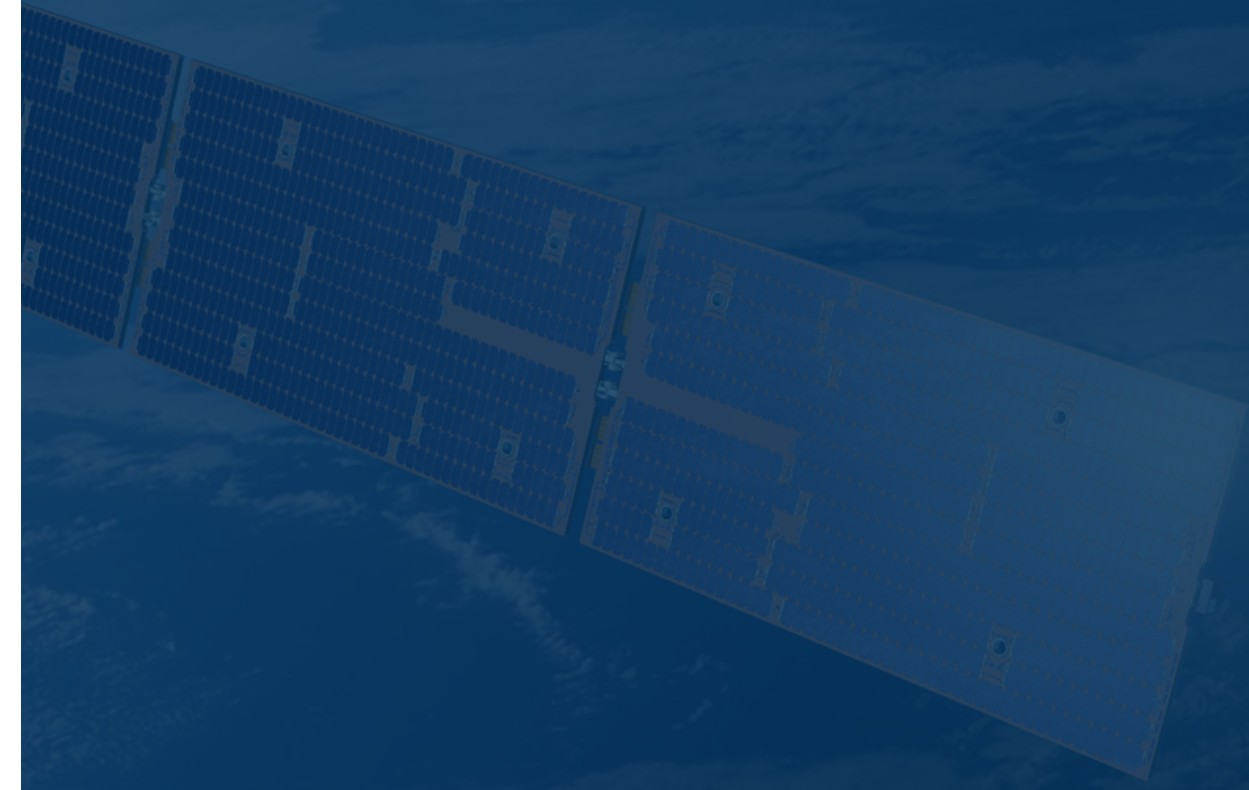
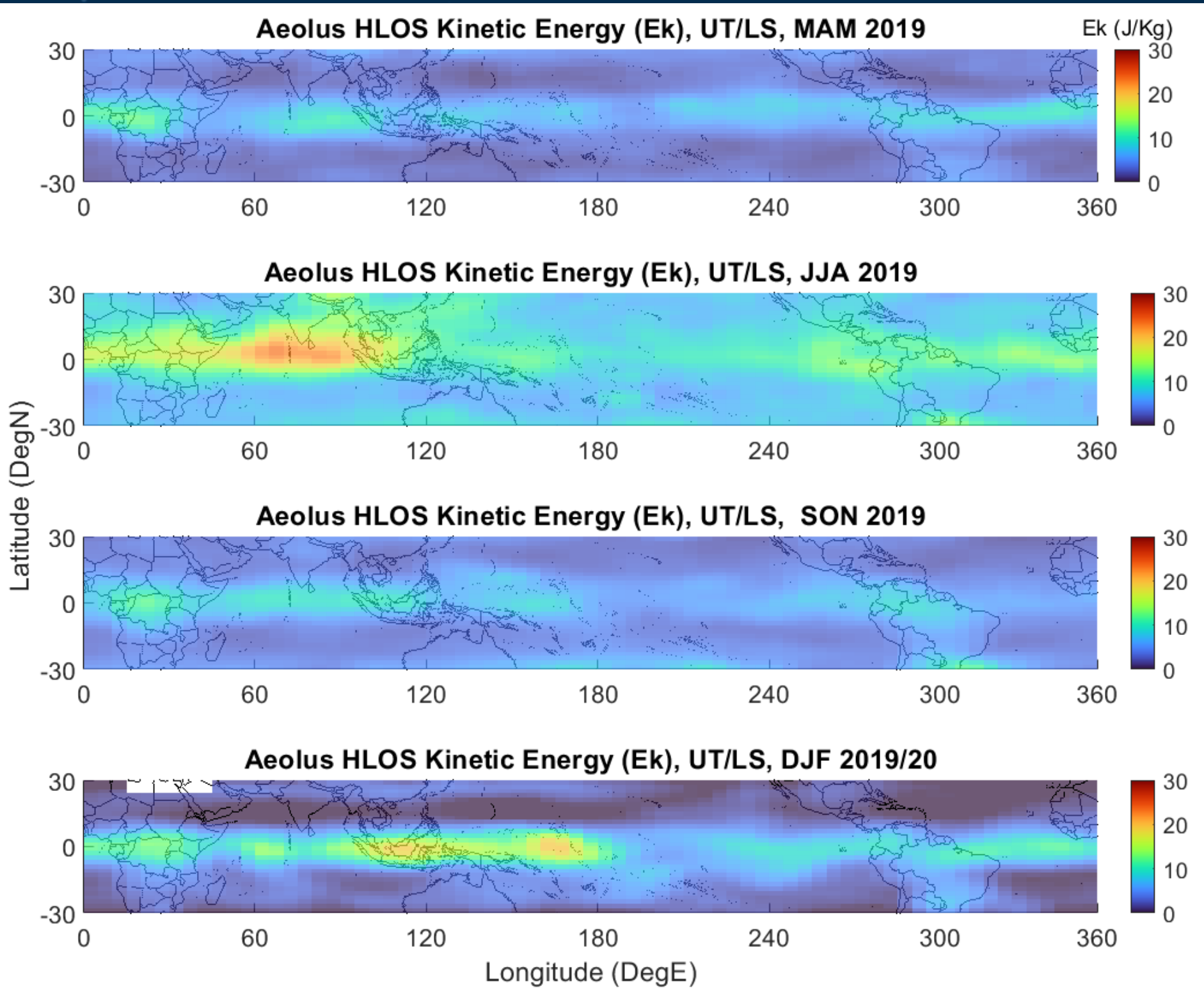
AUSTRAL SUMMER



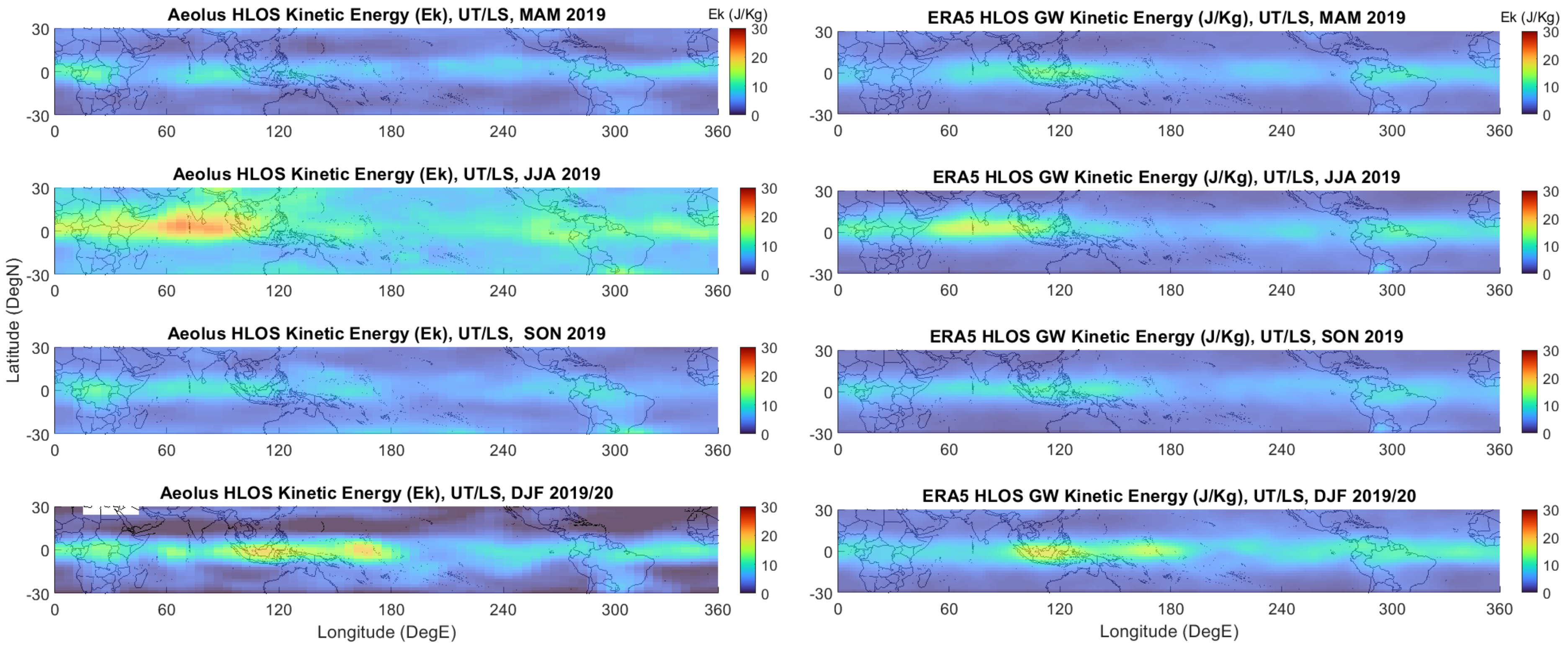
Distributions don't correlate perfectly ($E_k \neq E_p$)

Pattern similarities are limited but hotspots are consistent

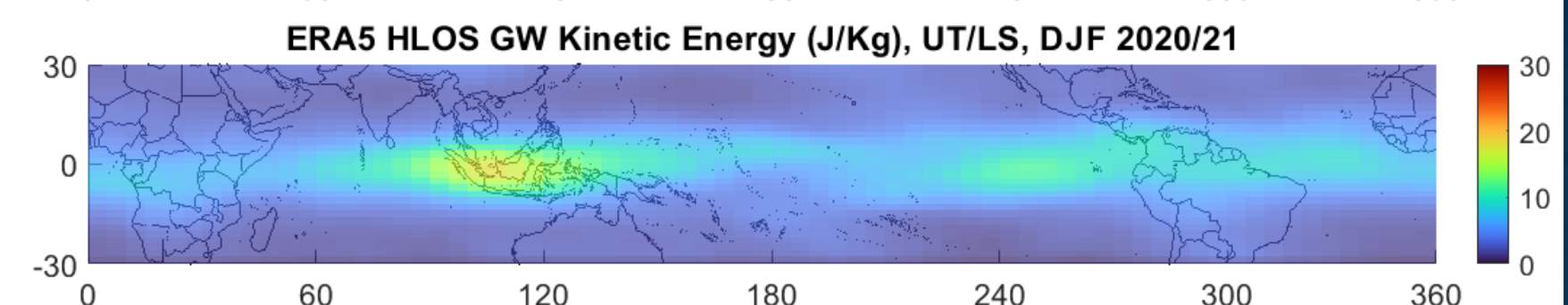
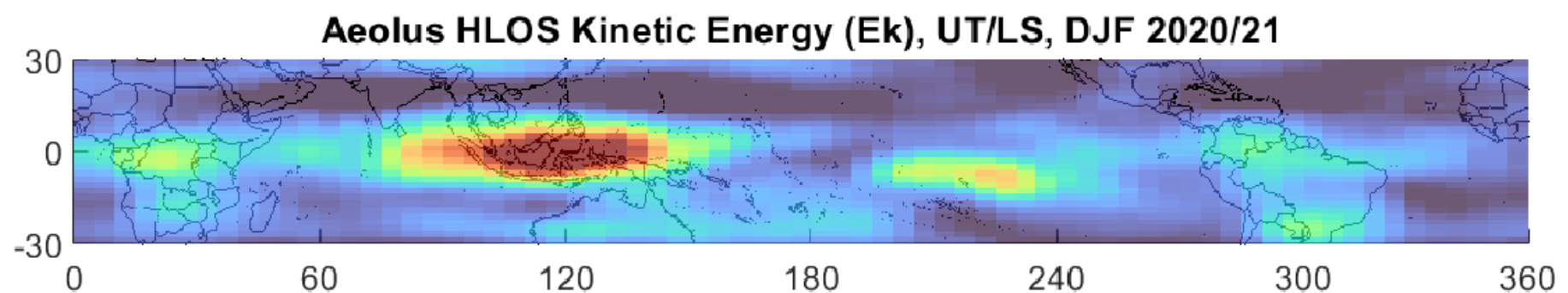
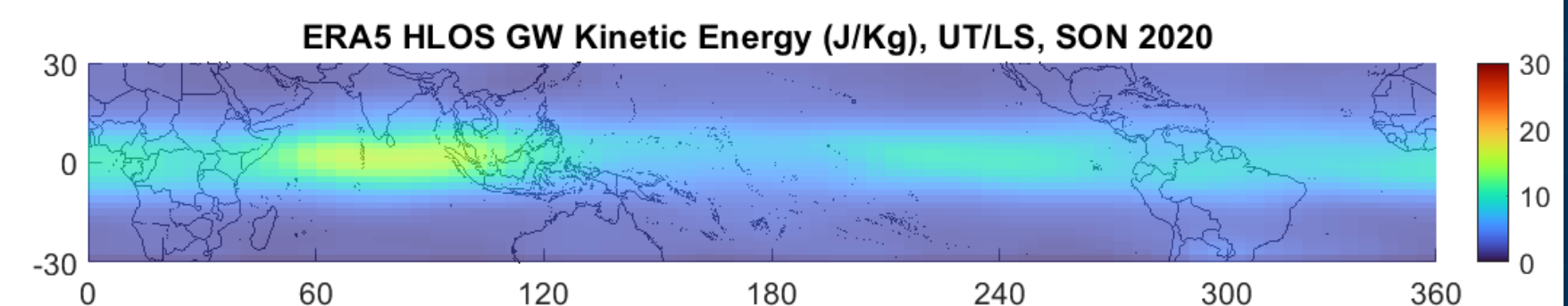
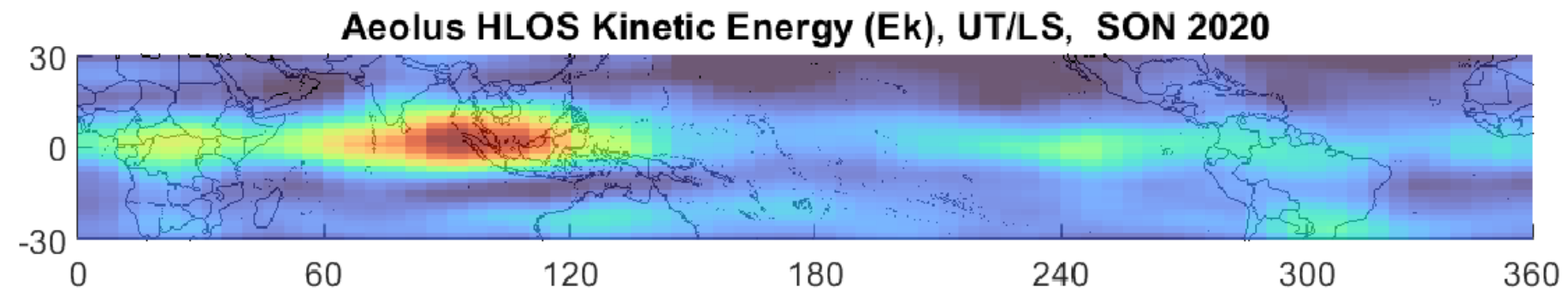
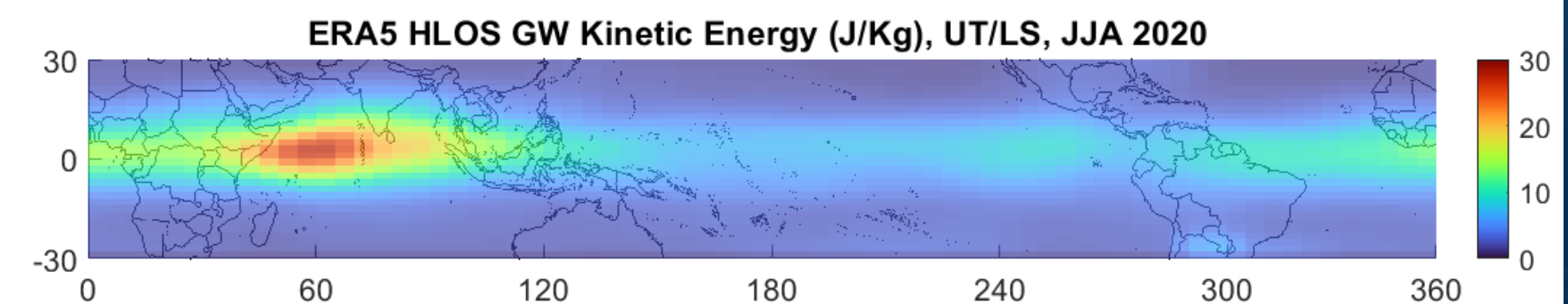
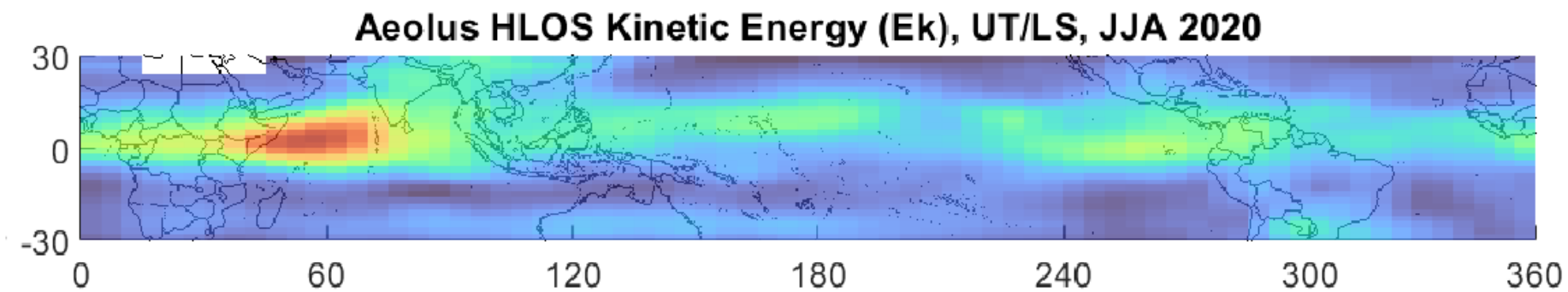
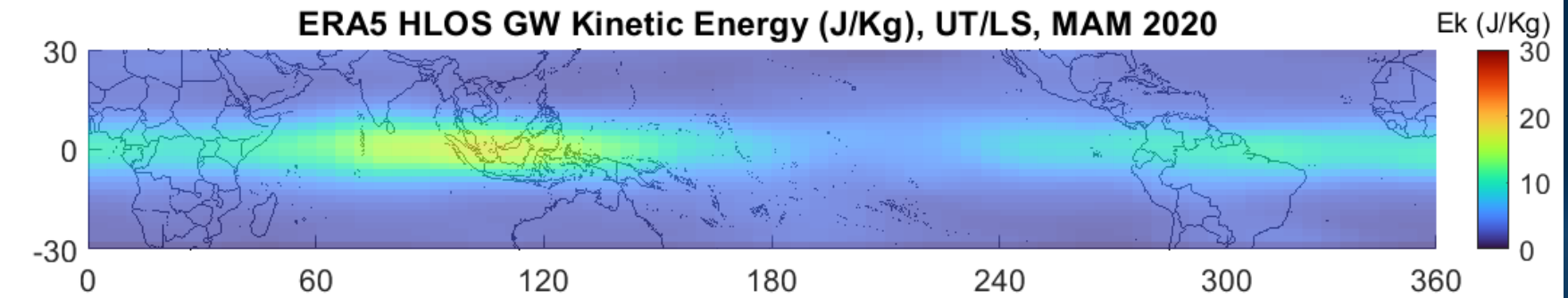
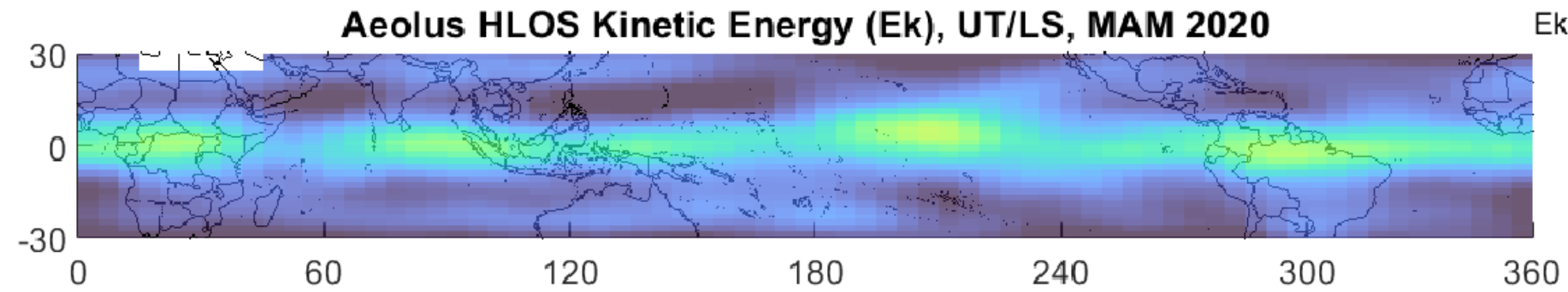
ERA5 COMPARISON



ERA5 COMPARISON



ERA5 COMPARISON



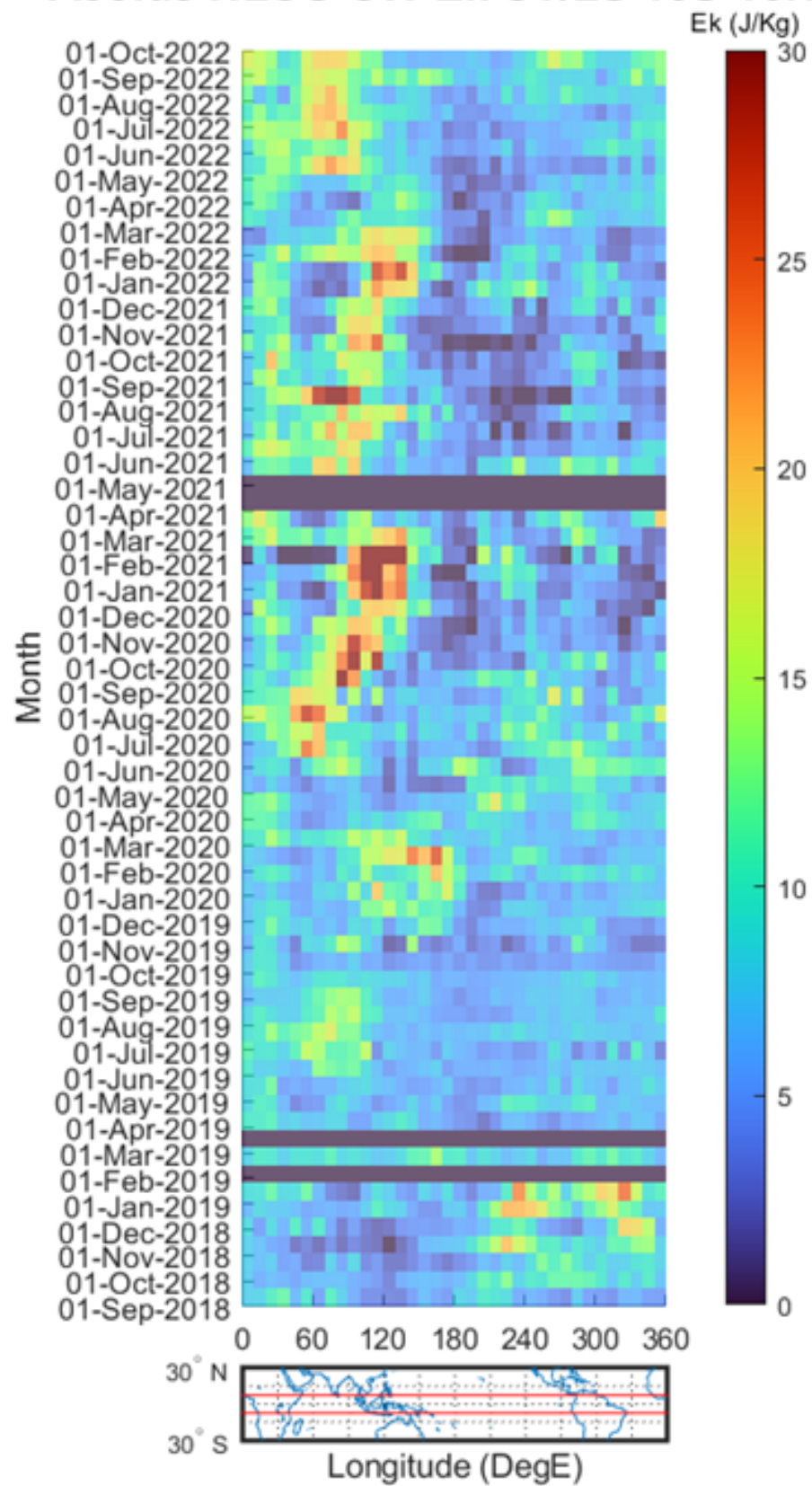
Longitude (DegE)

Longitude (DegE)

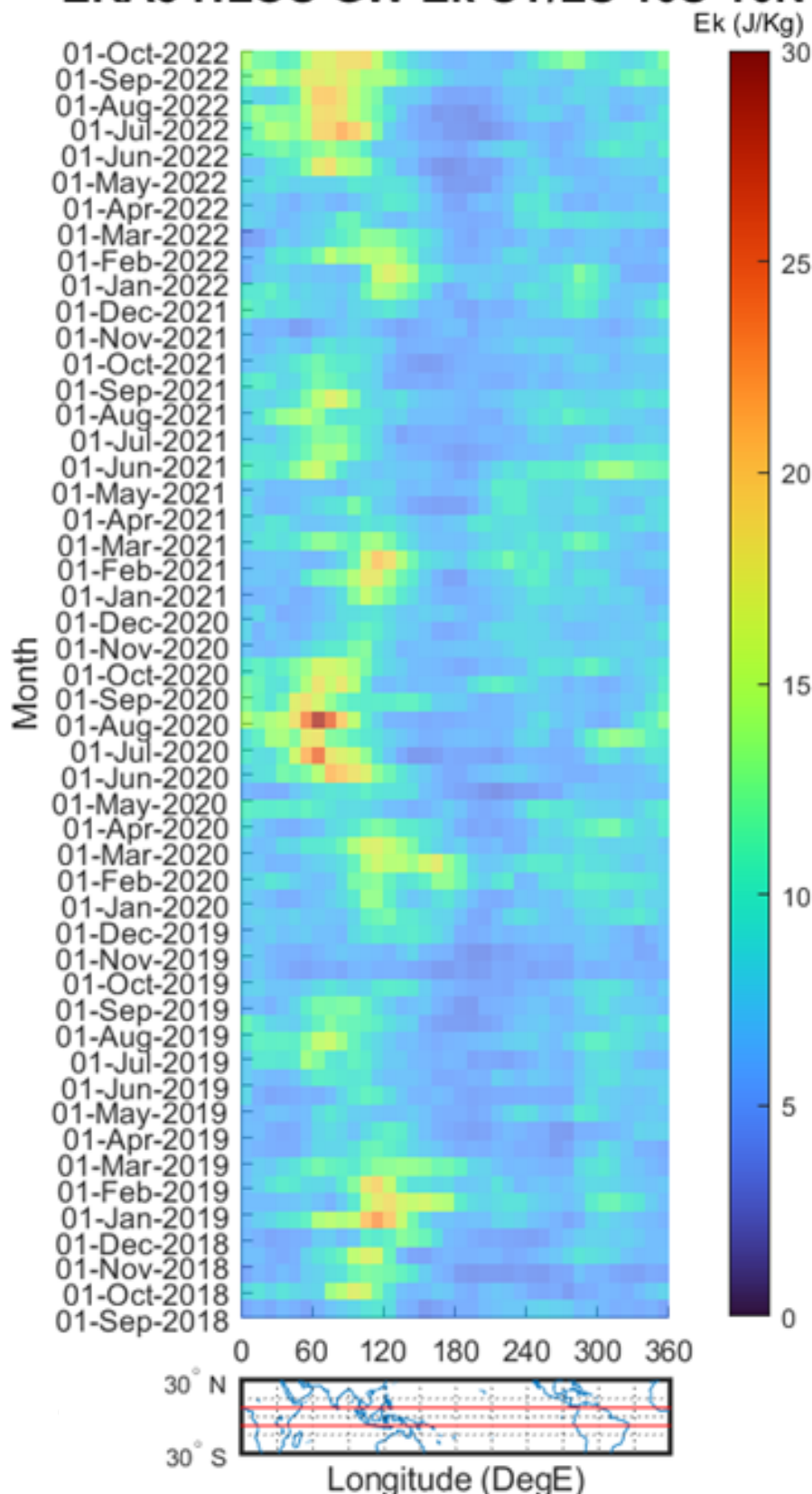
Latitude (DegN)

HOVMOLLER PLOT EK 9 KM

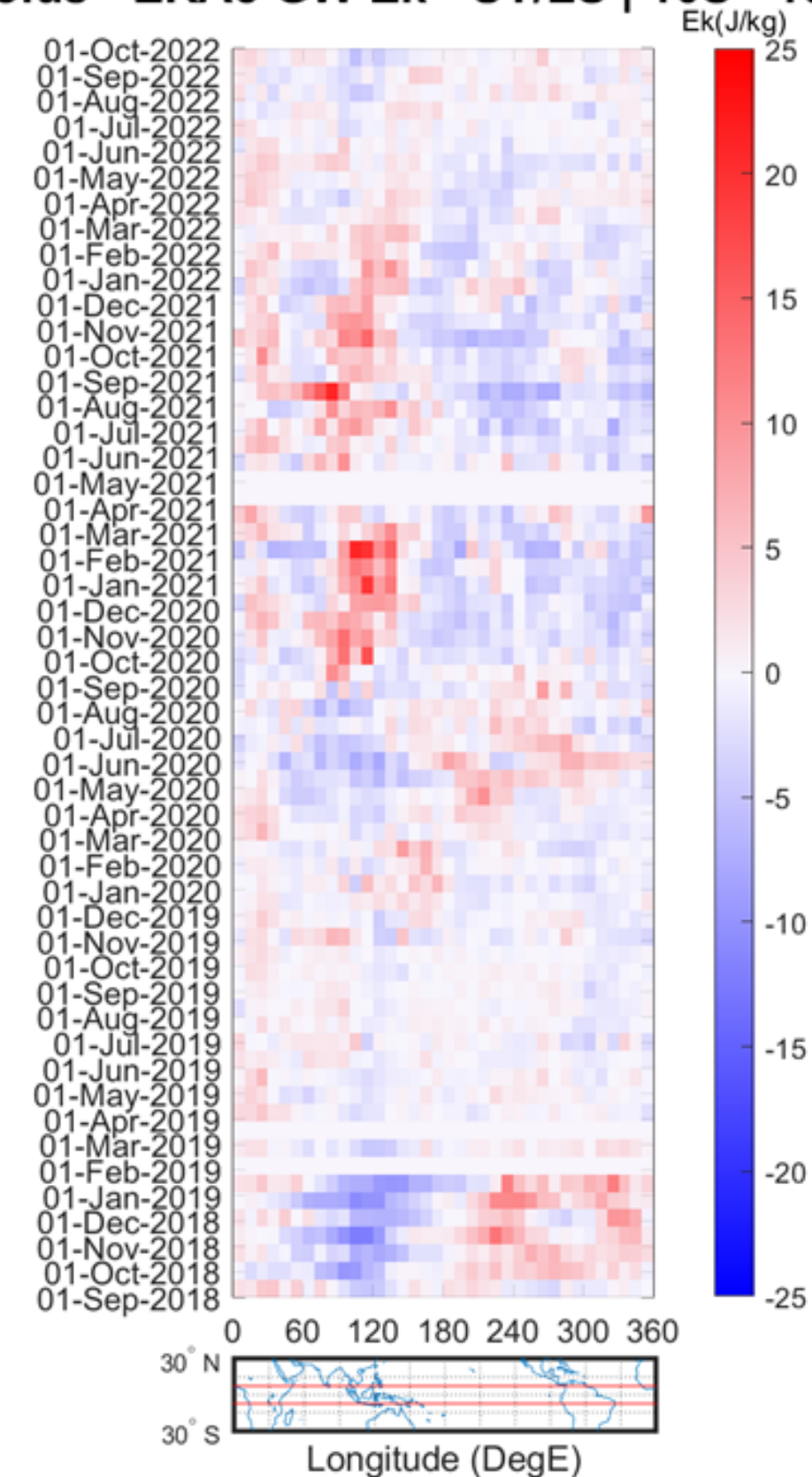
Aeolus HLOS GW Ek UT/LS 10S-10N



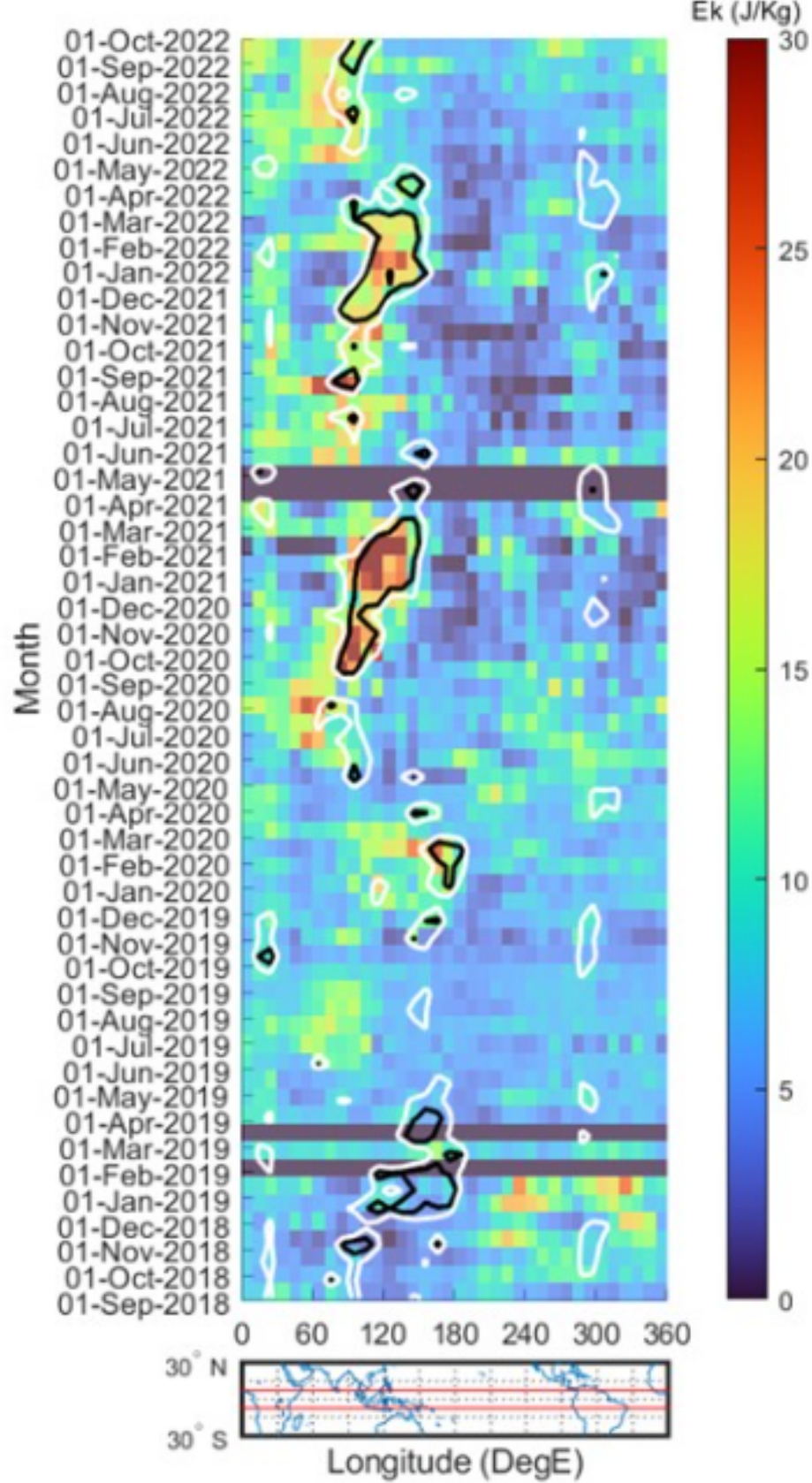
ERA5 HLOS GW Ek UT/LS 10S-10N



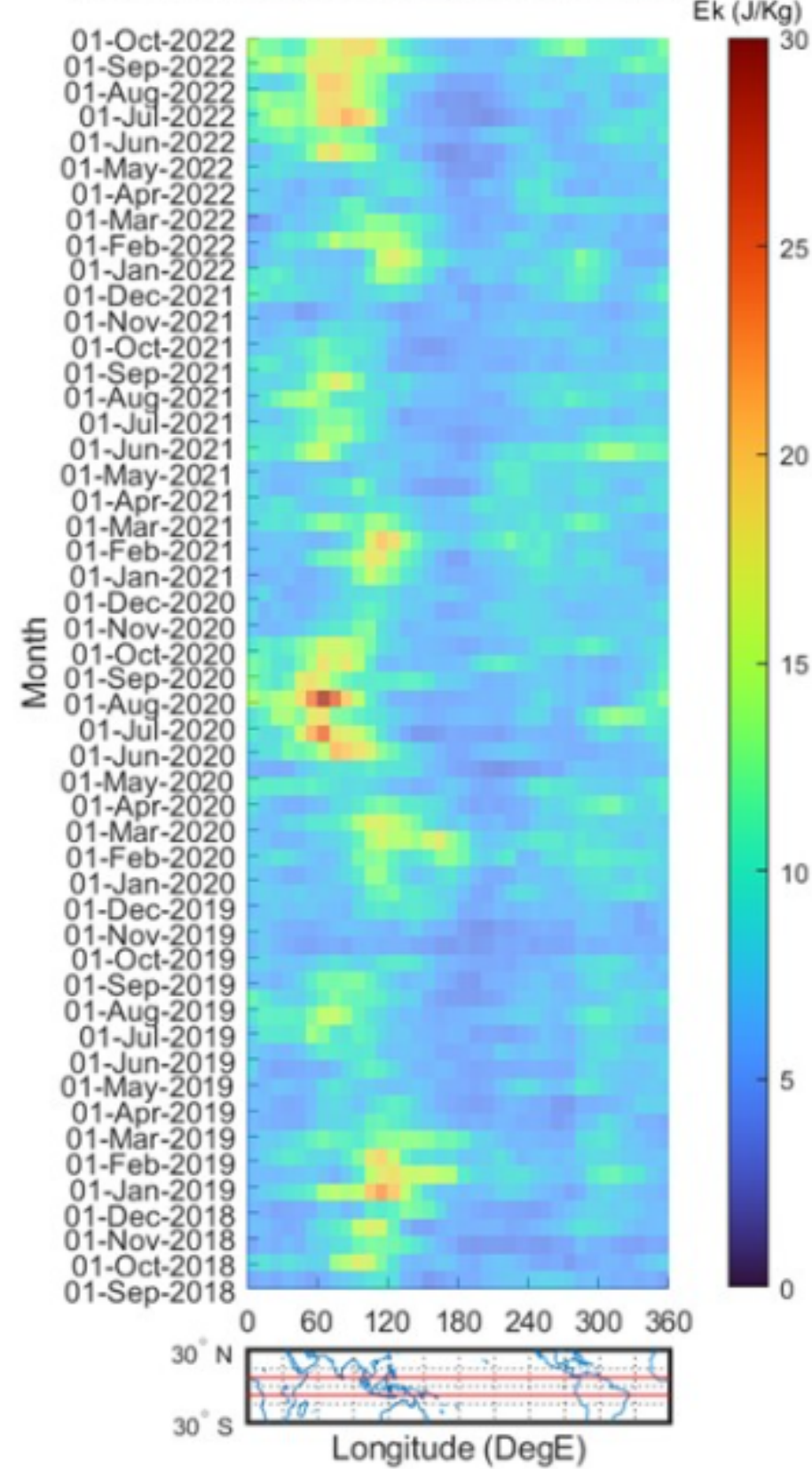
Aeolus - ERA5 GW Ek - UT/LS | 10S - 10N



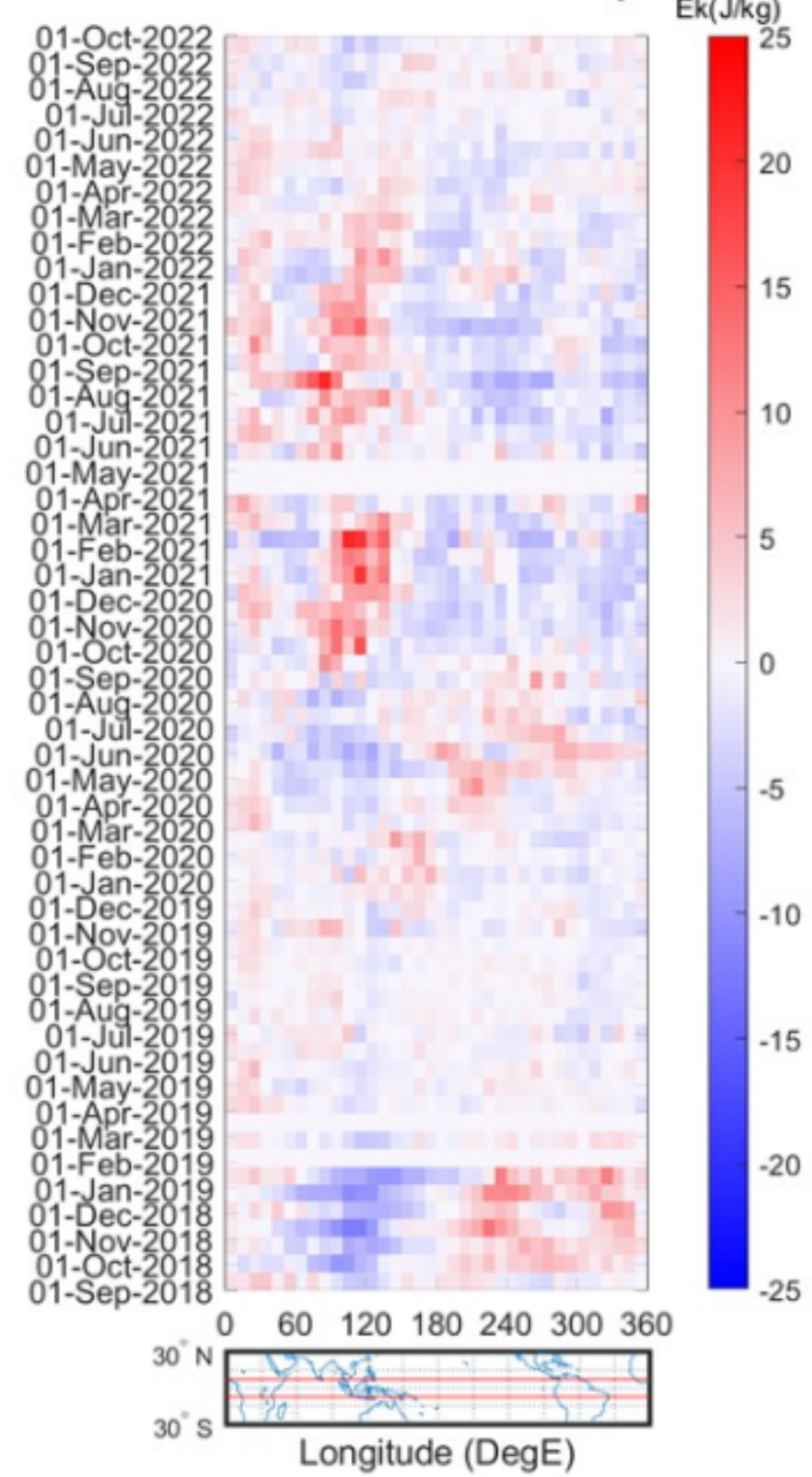
Aeolus HLOS GW Ek UT/LS 10S-10N



ERA5 HLOS GW Ek UT/LS 10S-10N

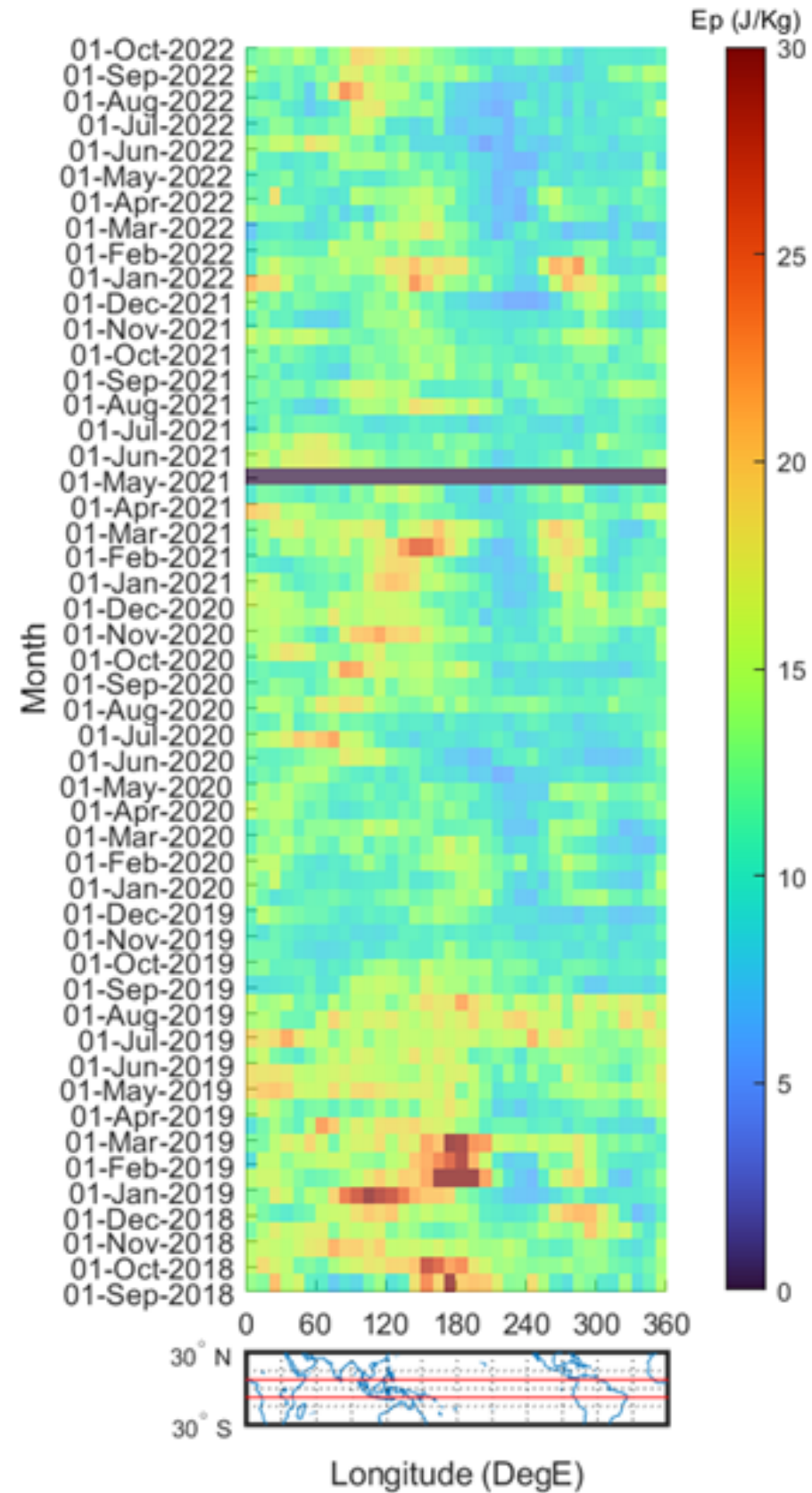


Aeolus - ERA5 GW Ek - UT/LS | 10S - 10N

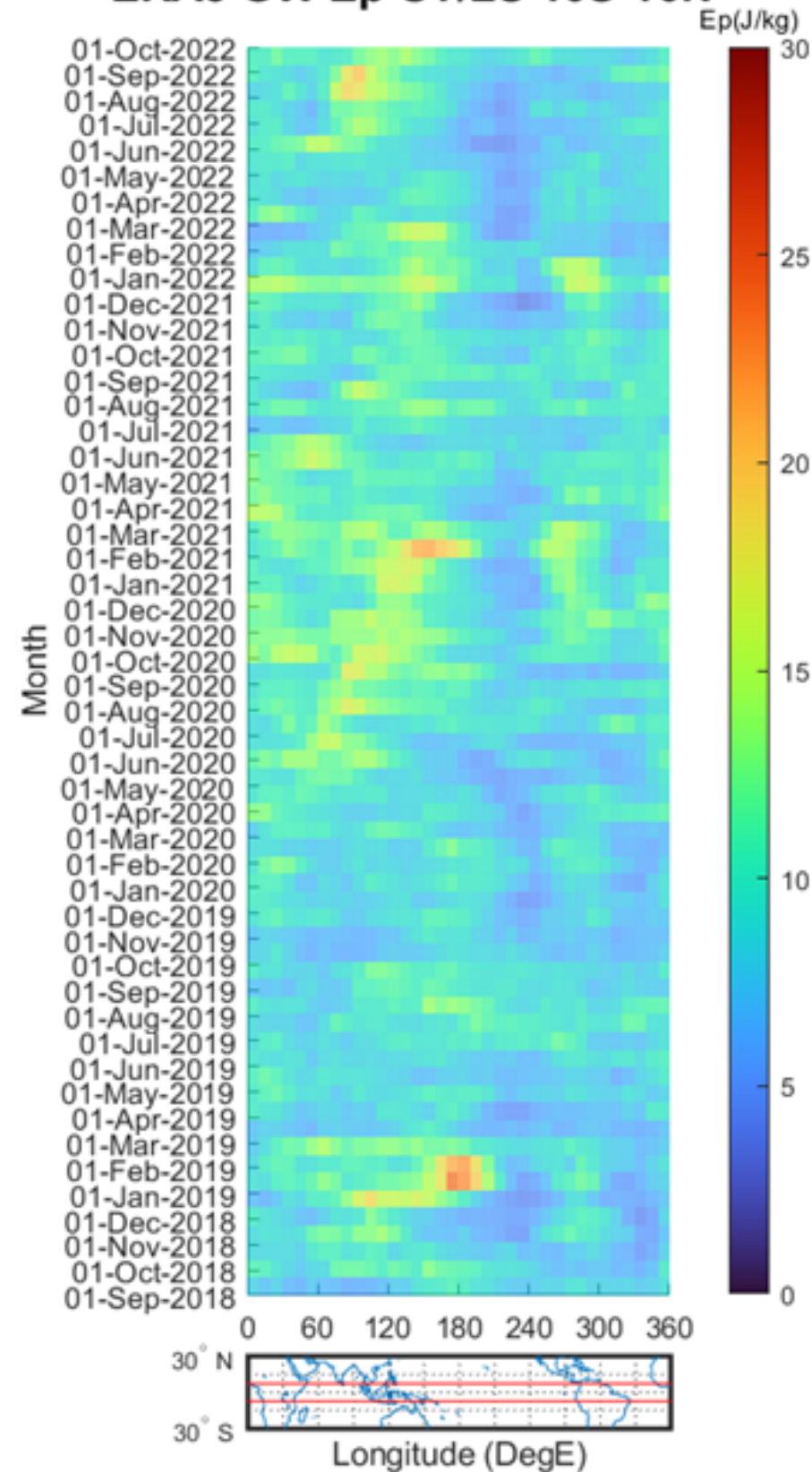


HOVMOLLER PLOT EP 9 KM

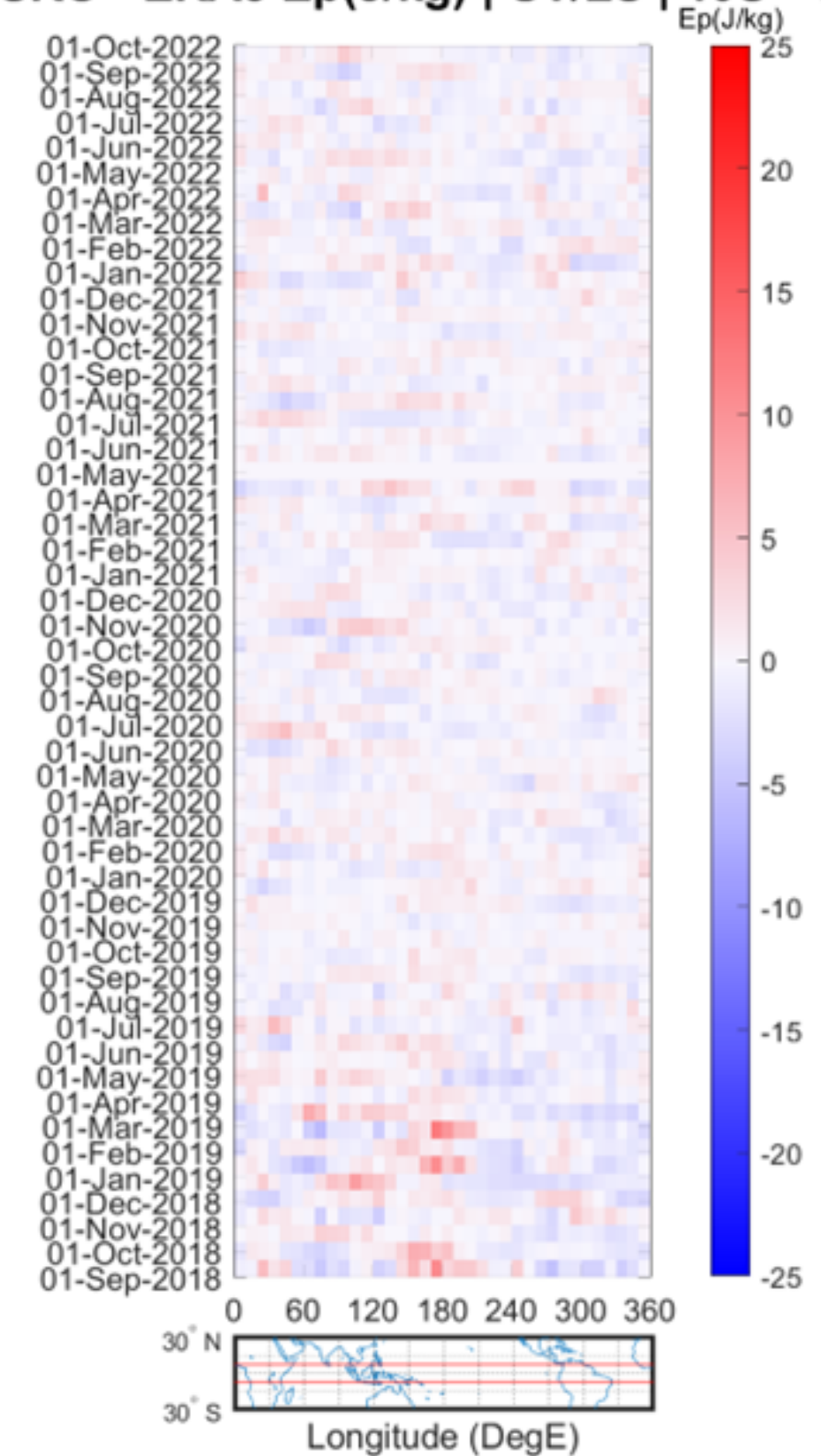
GNSS-RO GW Ep UT/LS 10S-10N



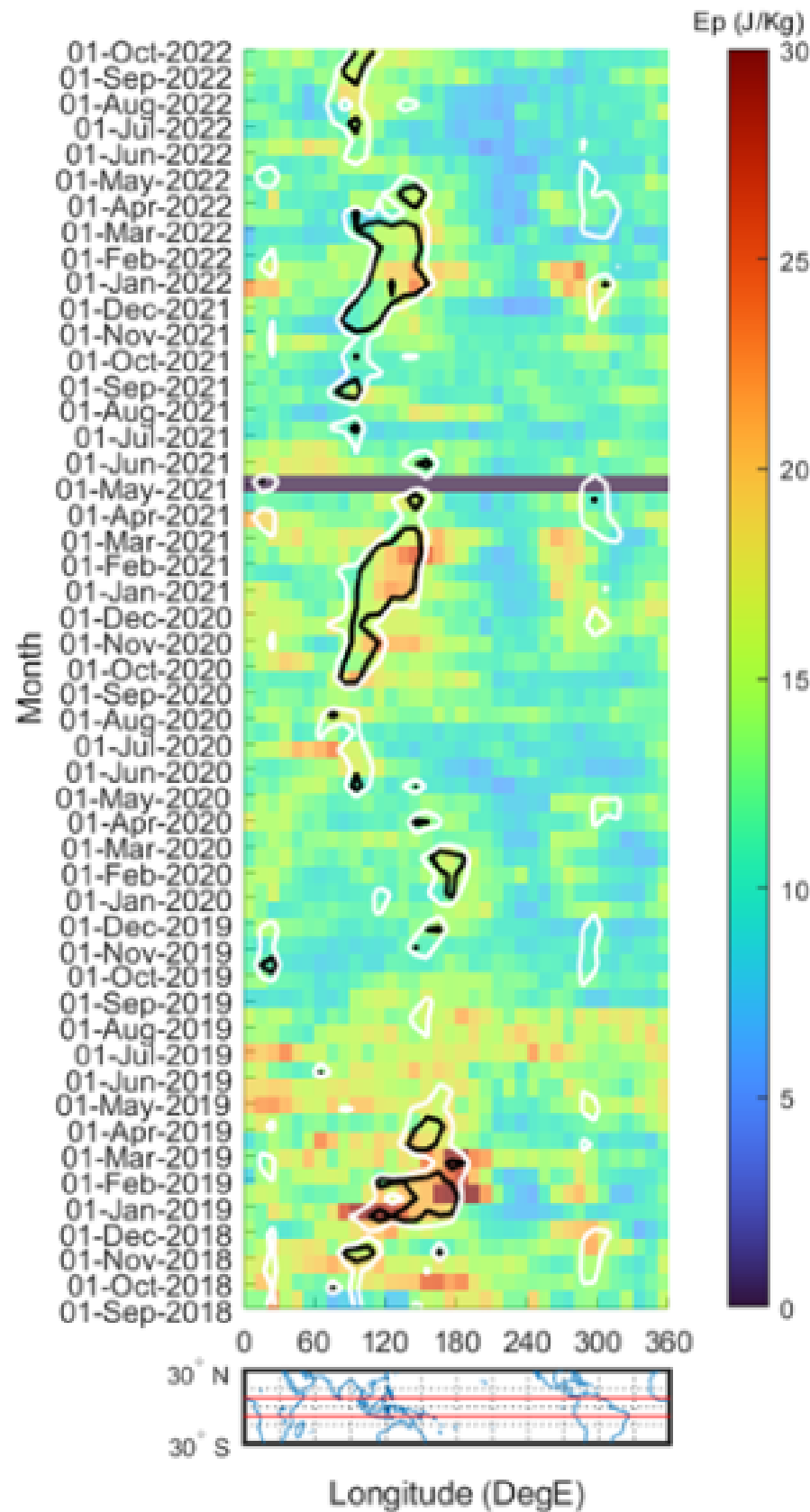
ERA5 GW Ep UT/LS 10S-10N



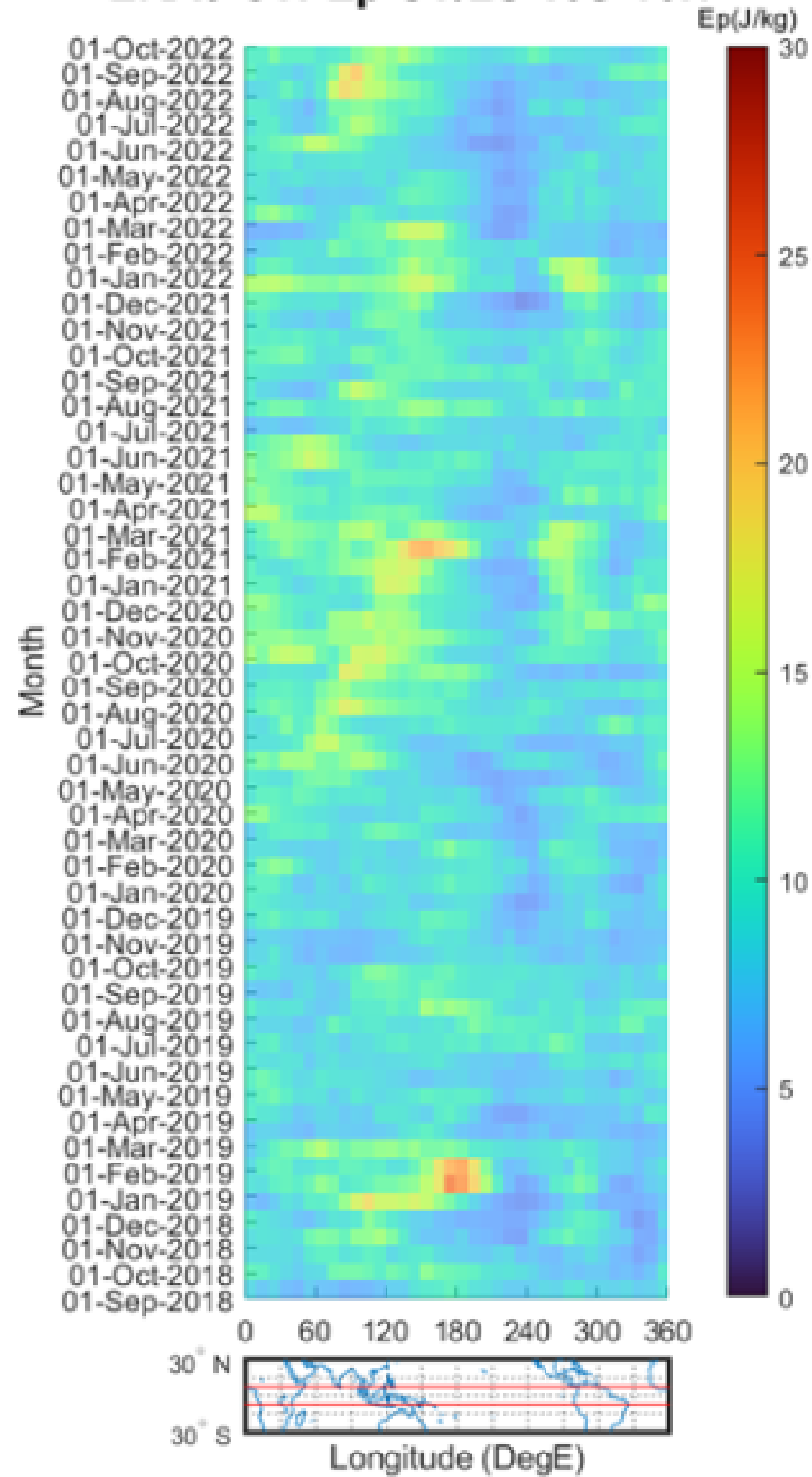
GNSSRO - ERA5 Ep(J/kg) | UT/LS | 10S - 10N



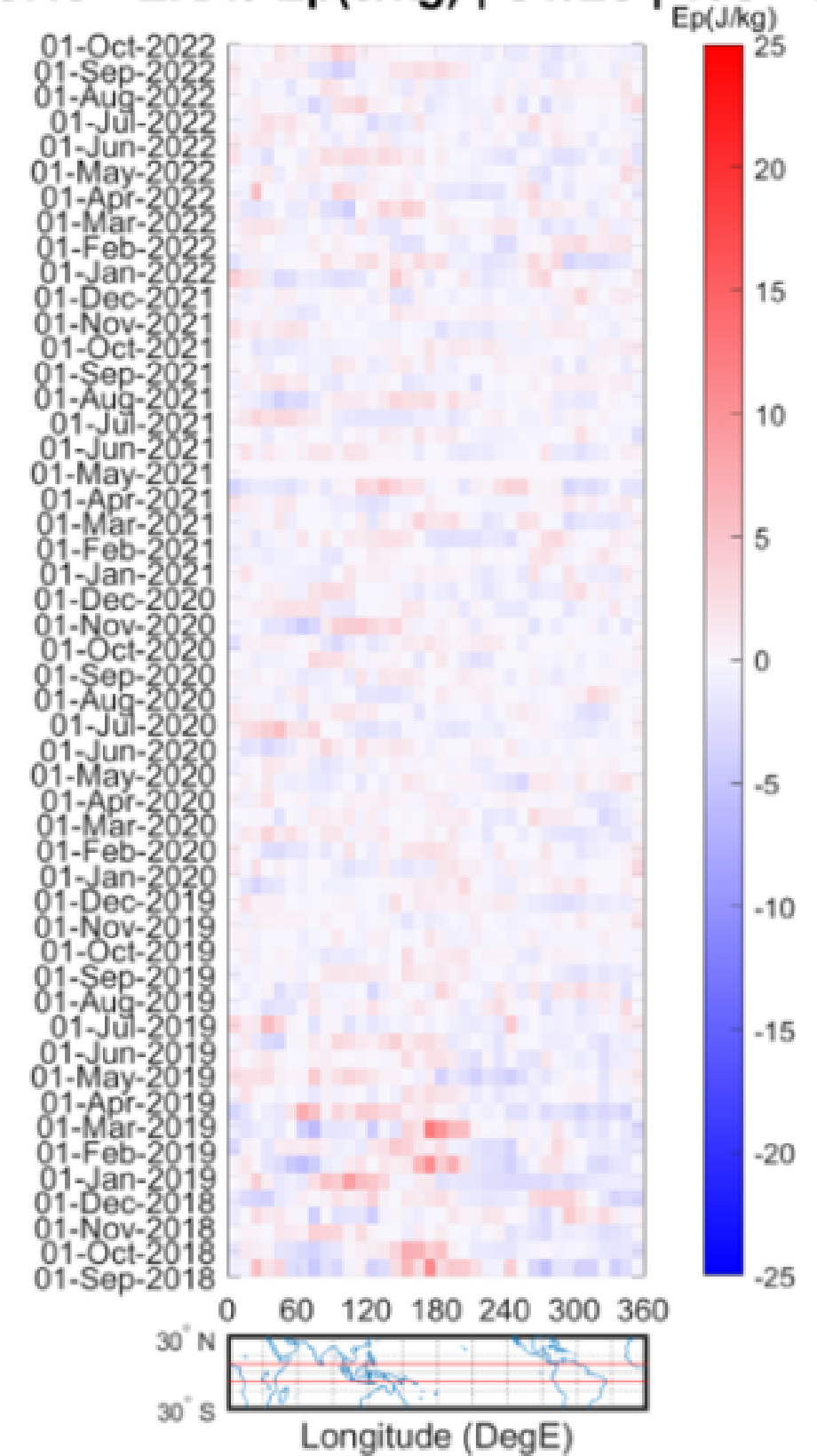
GNSS-RO GW Ep UT/LS 10S-10N



ERA5 GW Ep UT/LS 10S-10N

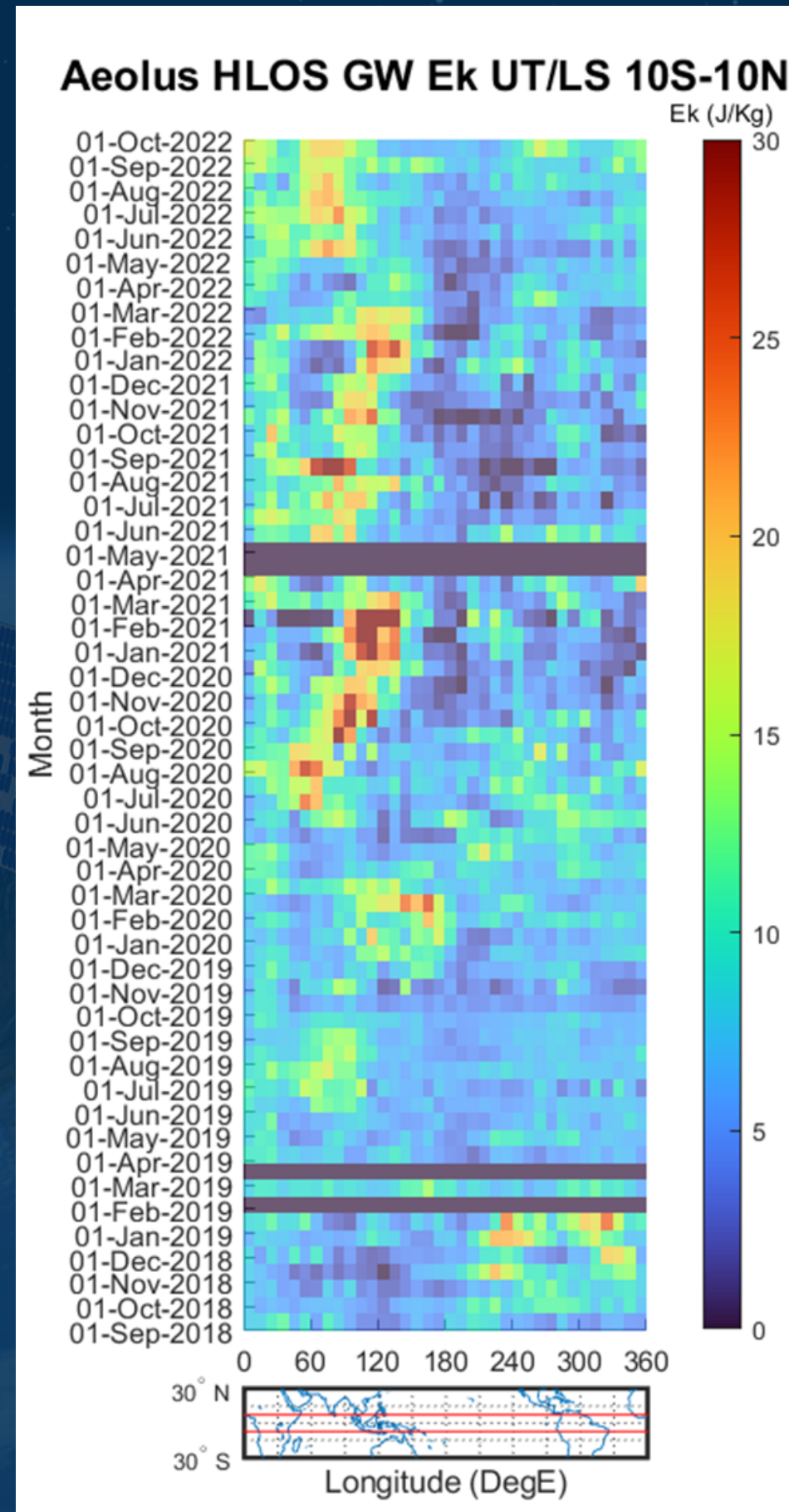
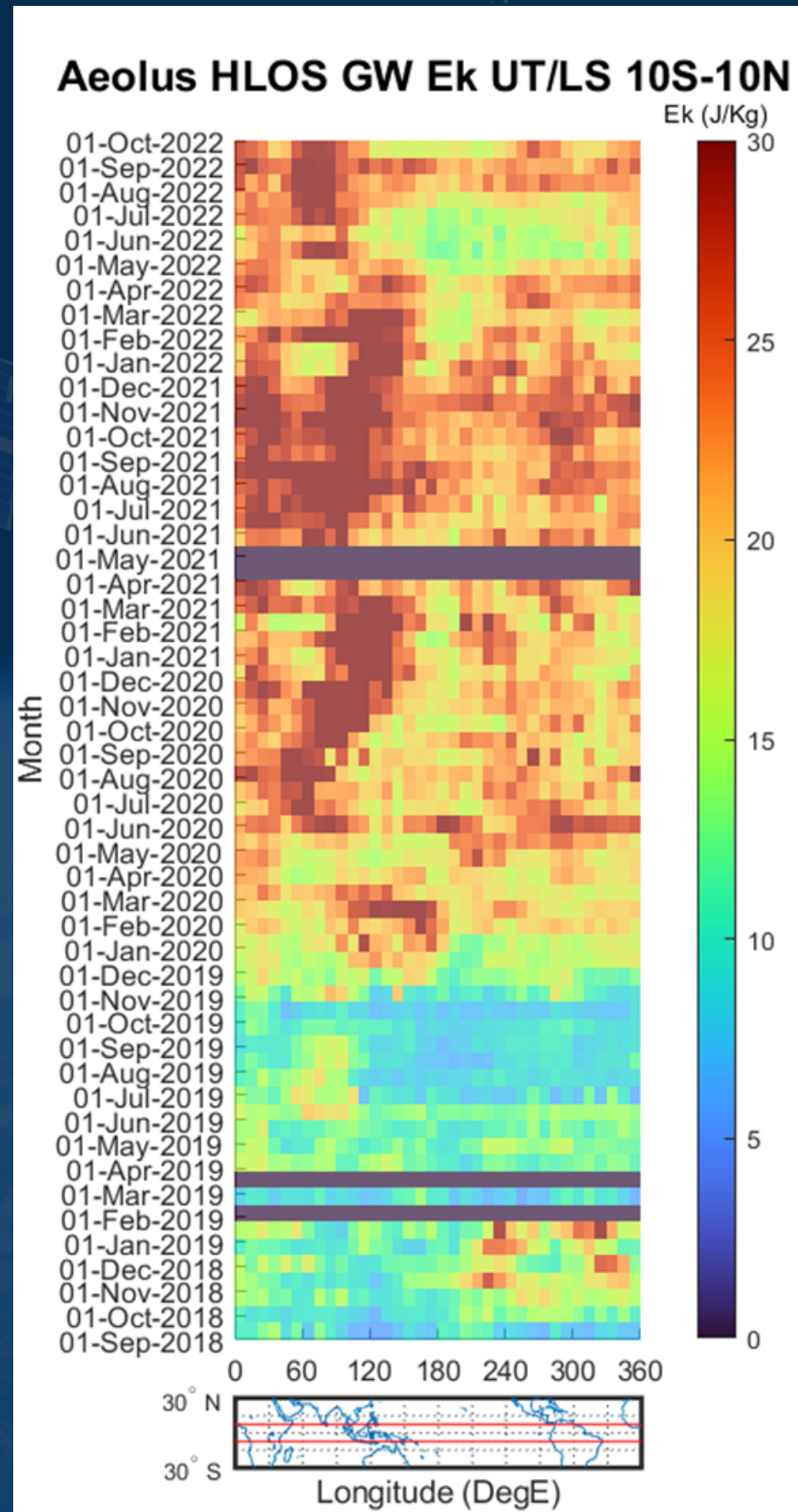


GNSSRO - ERA5 Ep(J/kg) | UT/LS | 10S - 10N



- Use of Aeolus Rayleigh clear channel (clear sky) winds for processing and retrieval of Kinetic Energy from Gravity Waves (Internal and Inertia).
- EK patterns showed by Aeolus are consistent with results from GNSS-RO EP and ERA5 EK and EP.
- The hotspots are primarily linked to convective phenomena, such as the MJO, based on OLR measurements.
- The ERA5 reanalysis model underestimates the EK in regions where convection is higher. This is not the case for EP, as the model assimilates GNSS-RO data.
- Utilizing Aeolus as a new data source to study convection-induced phenomena in poorly assimilated tropical regions, will offer substantial scientific benefits to models

NOISE CORRECTION



The noise correction is made from a zonal mean difference between Aeolus and ERA5

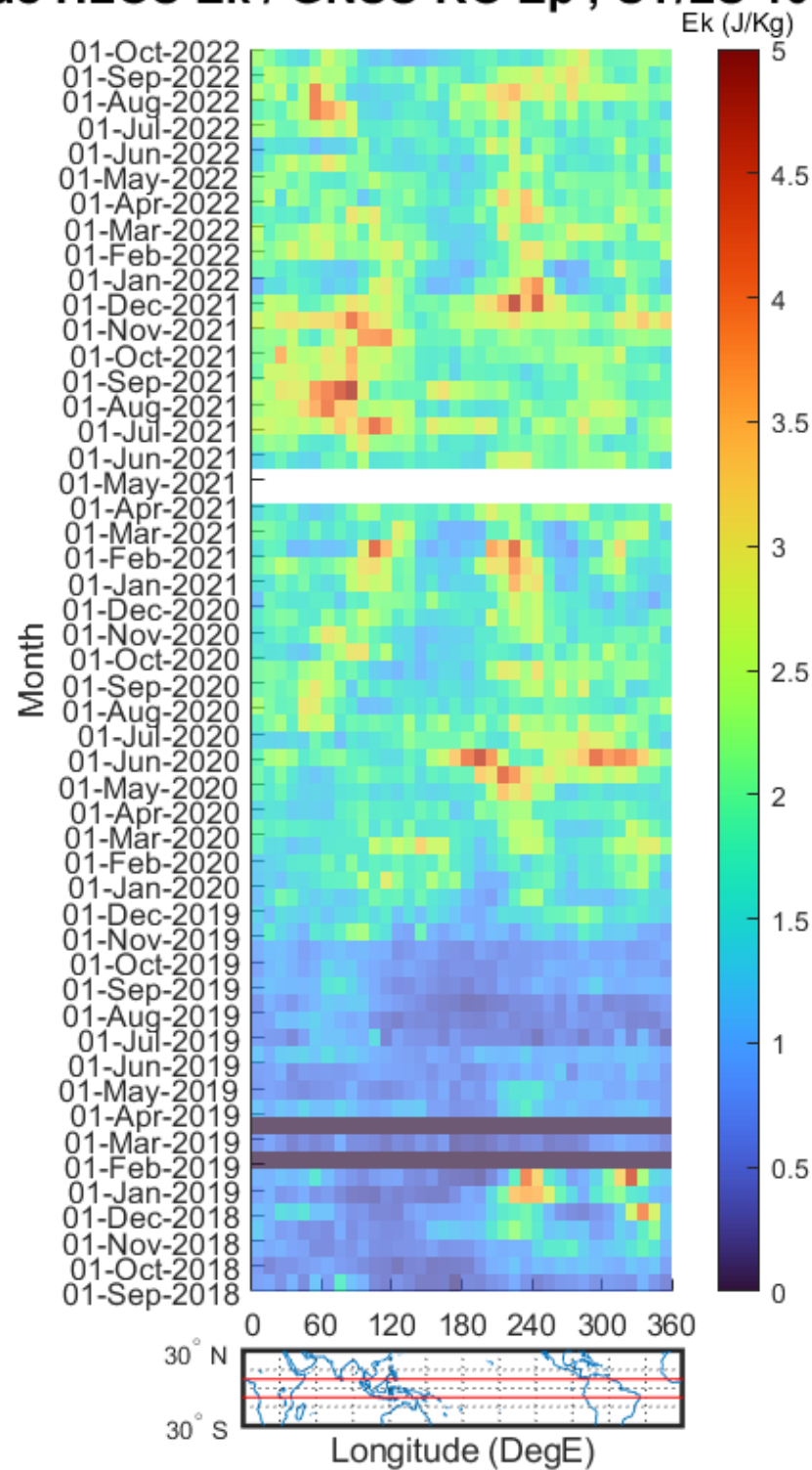
The difference is averaged over an entire line (3 weeks)

This method overcorrects areas of low value

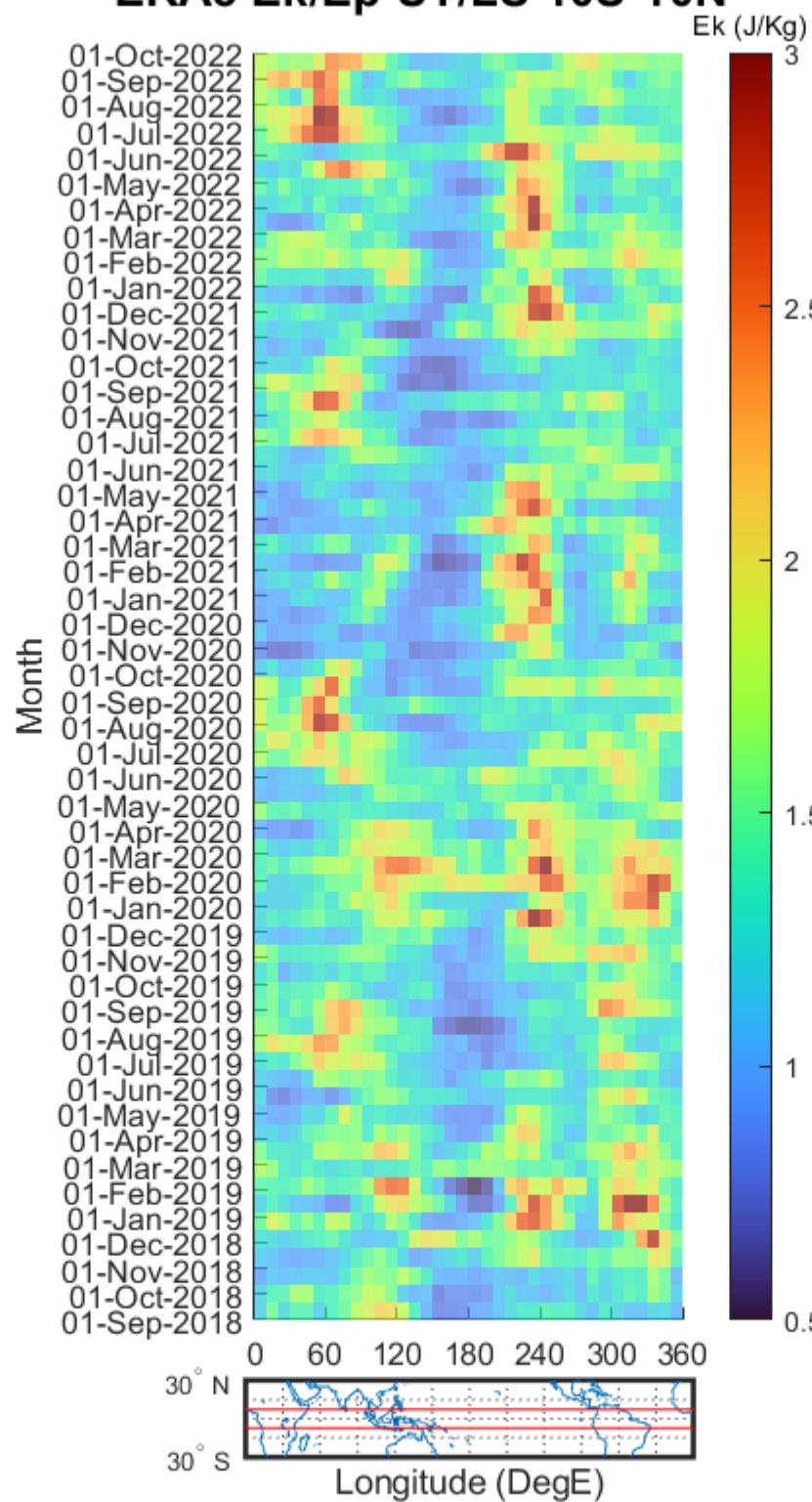
Allows for a good appreciation of the convection-related patterns

EK/EP RATIO

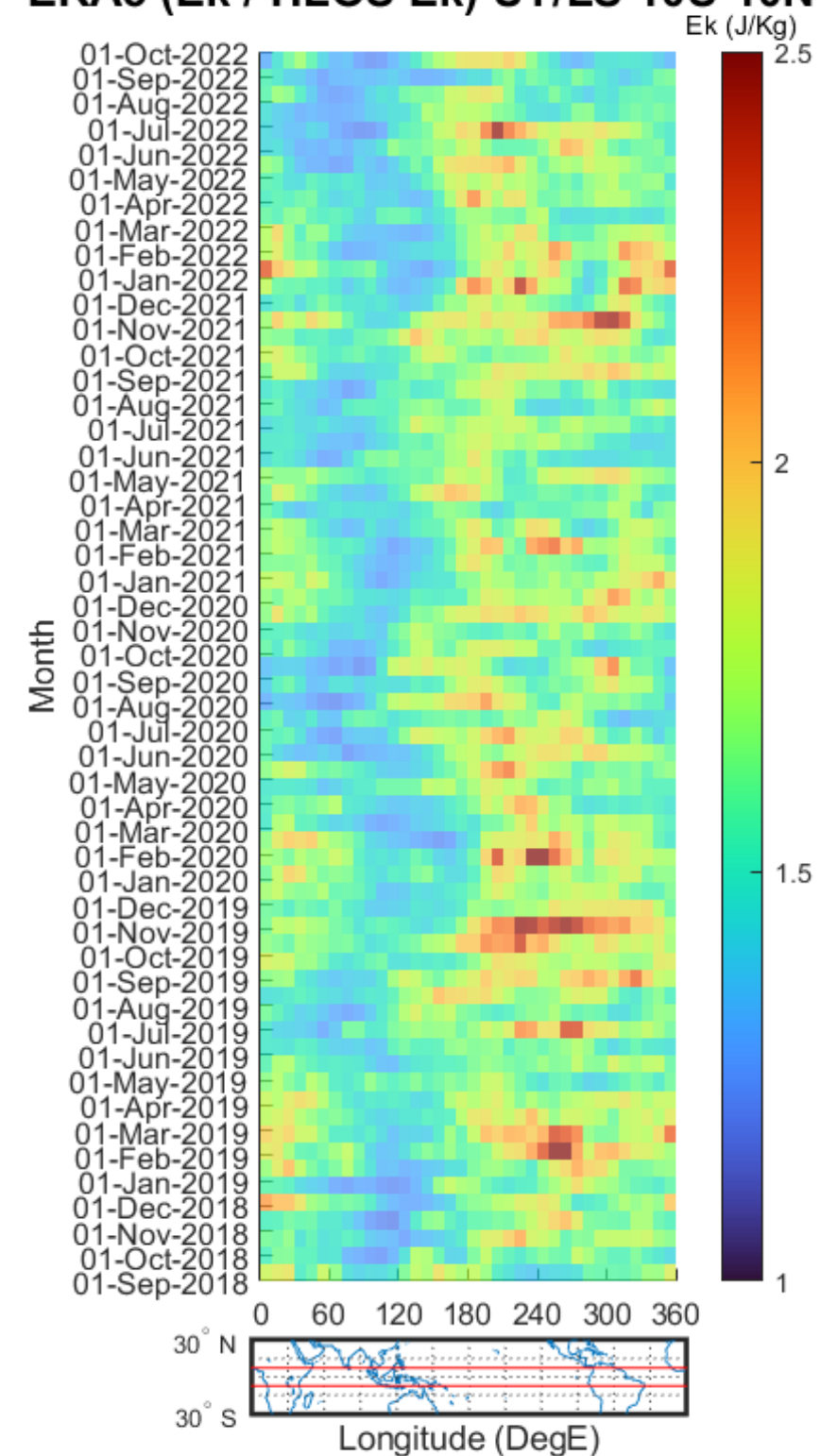
Aeolus HLOS Ek / GNSS-RO Ep , UT/LS 10S-10N



ERA5 Ek/Ep UT/LS 10S-10N



ERA5 (Ek / HLOS Ek) UT/LS 10S-10N



Mean EK/EP Ratio : 1.63

1.43

1.6