The electrodynamic influence of thermospheric winds in the daytime ionosphere

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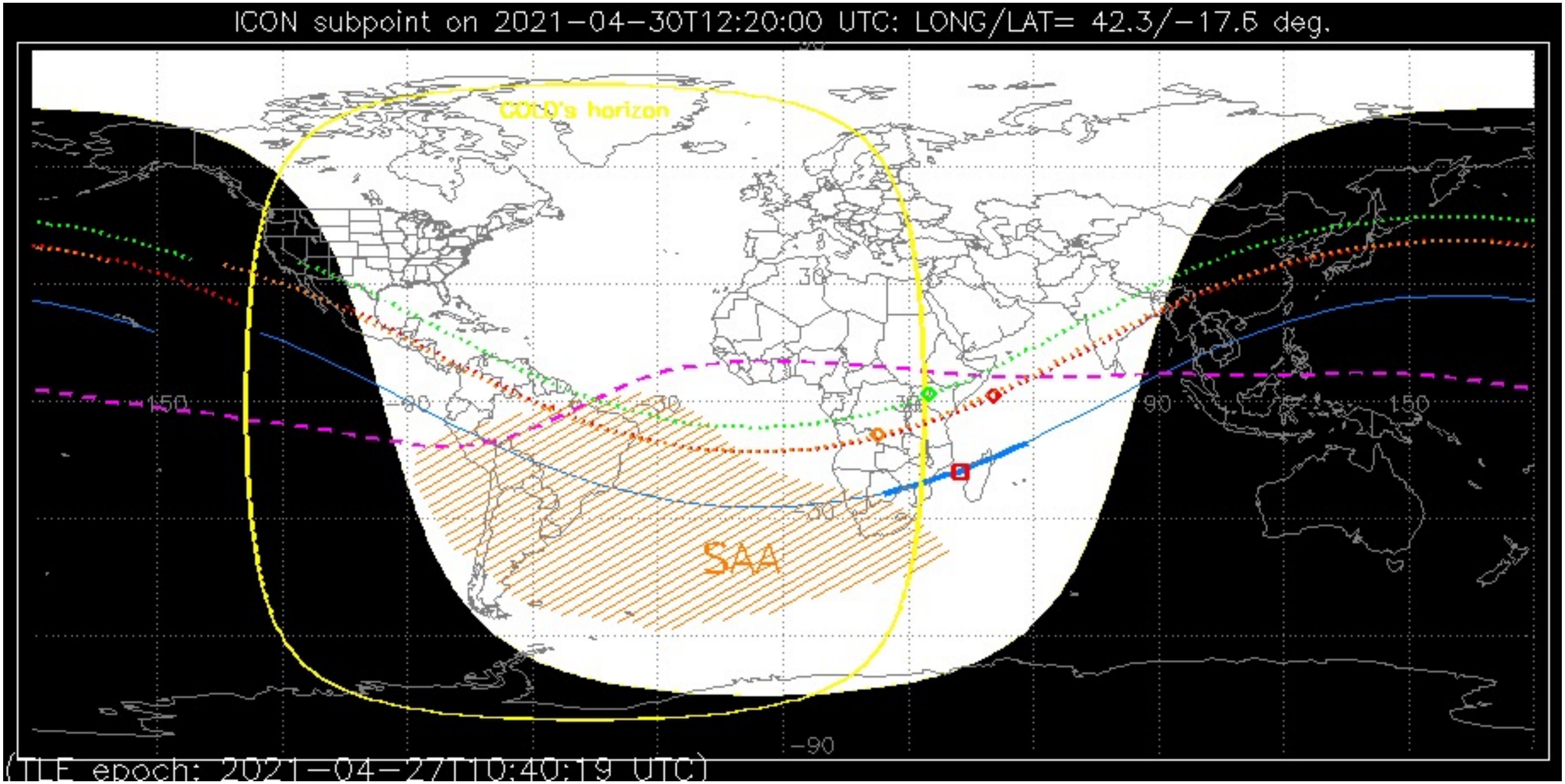
The NASA ICON Observatory provides all data used in this presentation

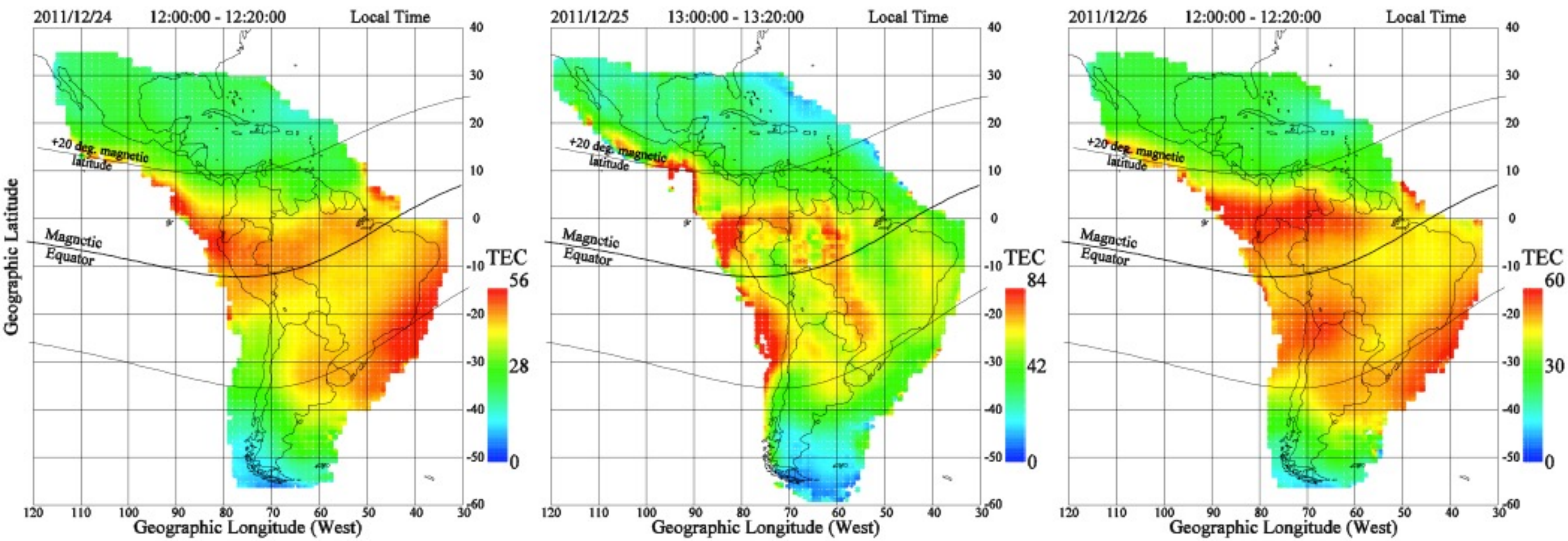


ICON is currently over Africa, exiting the SAA.

It is measuring the thermospheric wind field from 90-300 km altitude at 30s cadence and 500-km horizontal resolution with ~ 5 m/sec precision.

It is also measuring the plasma drift at the satellite (585 km) with 4-s cadence with similar precision.

Motivation



- ❑ LISN Network vTEC – PI Cesar Valladares, Boston College
- ❑ Outstanding day-to-day variability in equatorial ionosphere while Dst = 0 nT
- ❑ Cause unknown!

To what degree are changes in the thermospheric wind responsible for these effects?

Objective – Directly assess the influence of the thermospheric wind dynamo

Question:

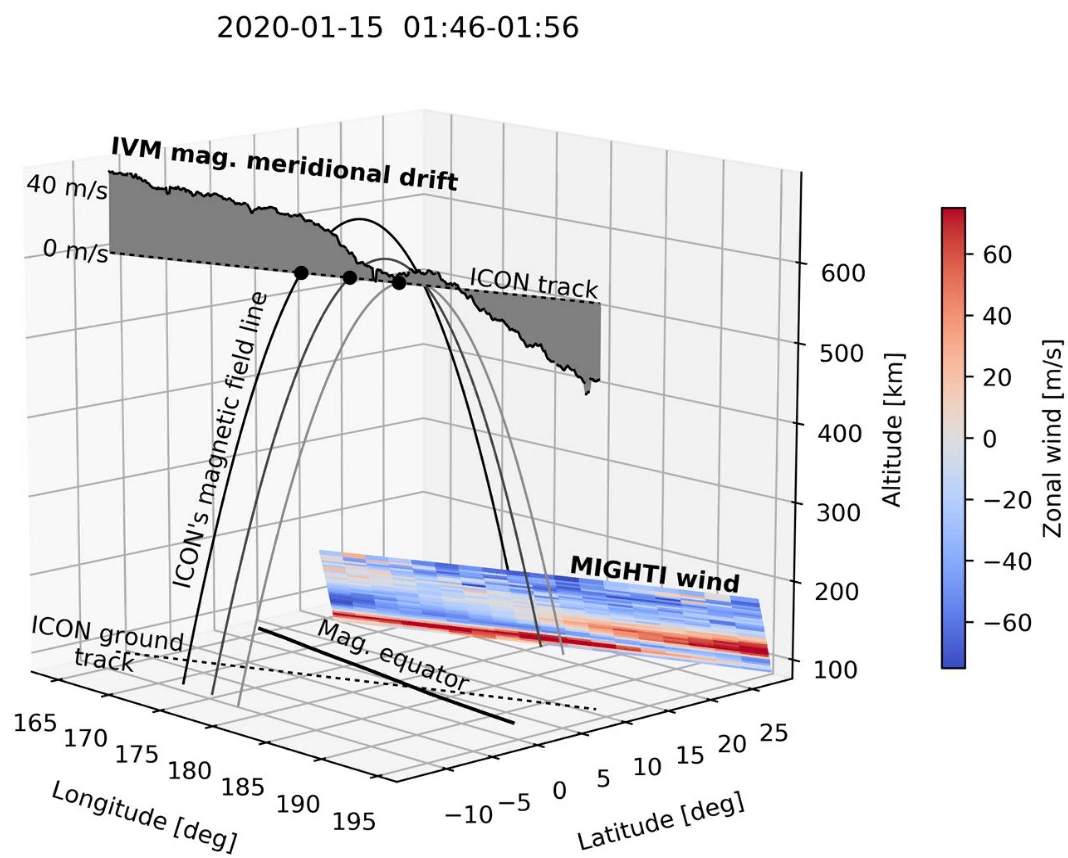
What is the effect of the thermospheric neutral wind on the equatorial ionosphere?

-You can address this question with climatological models and long-term observations

What is the **immediate, local** effect of the thermospheric neutral wind on the equatorial ionospheric **velocity field**?

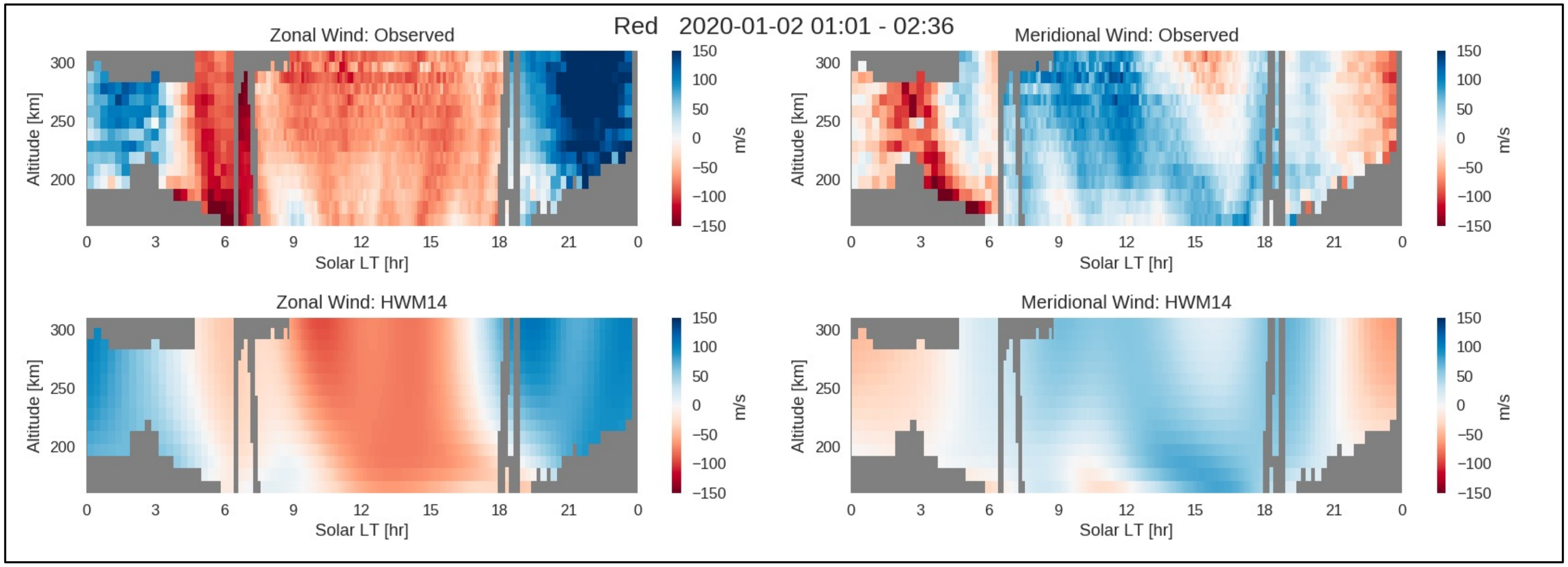
-You can answer this question with a complete set of observations

- Observations of thermospheric winds, uninterrupted over the 90-300 km altitude range, are now provided by ICON along with simultaneous plasma velocity and density measurements.
- These observations are directly comparable in crossings of the magnetic equator, where the winds are magnetically conjugate to the drift measurements.

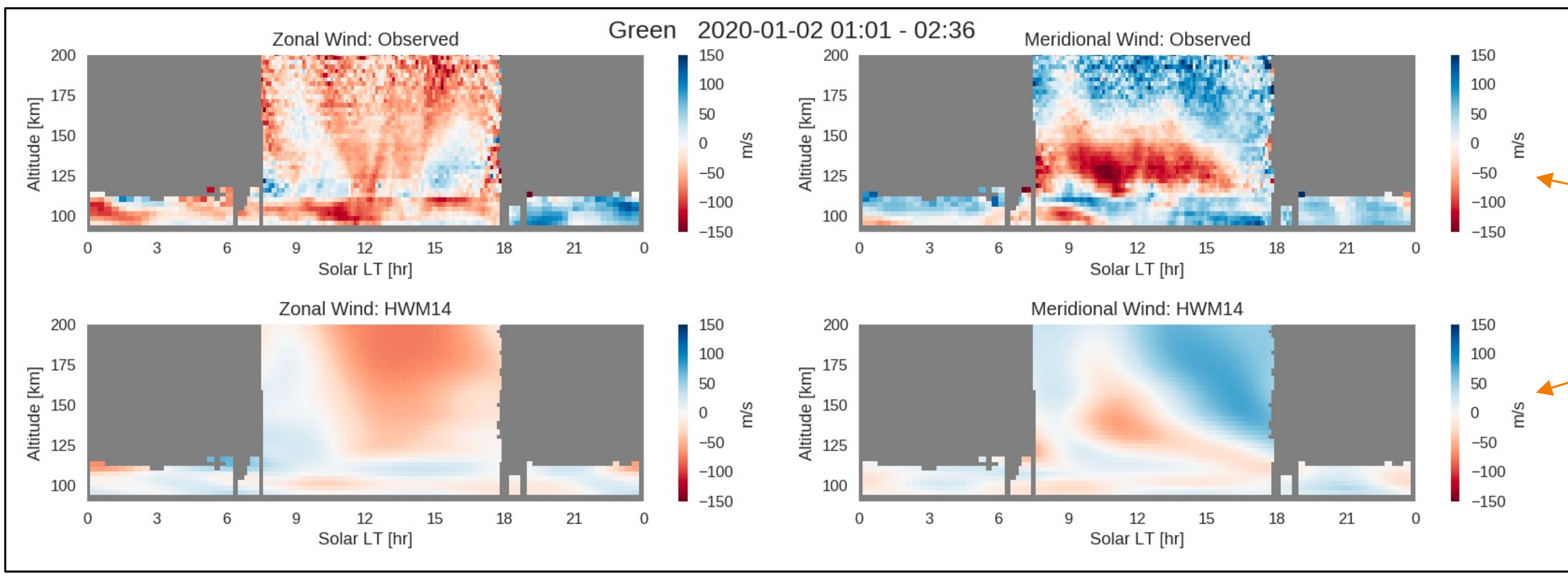


One orbit of MIGHTI winds

•Red emission

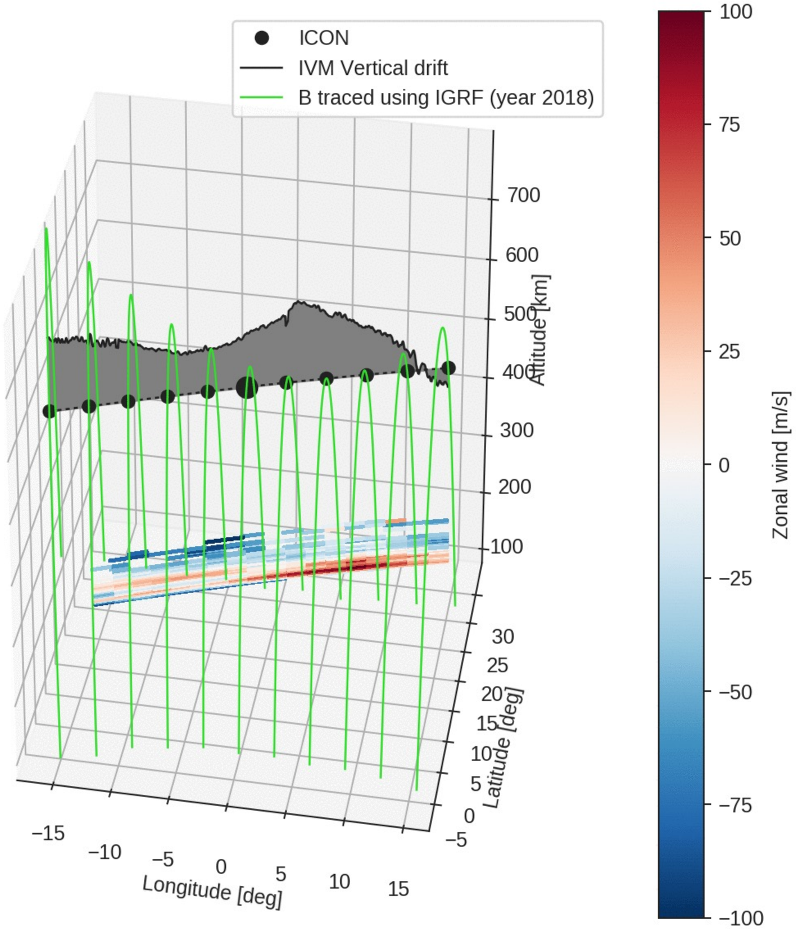


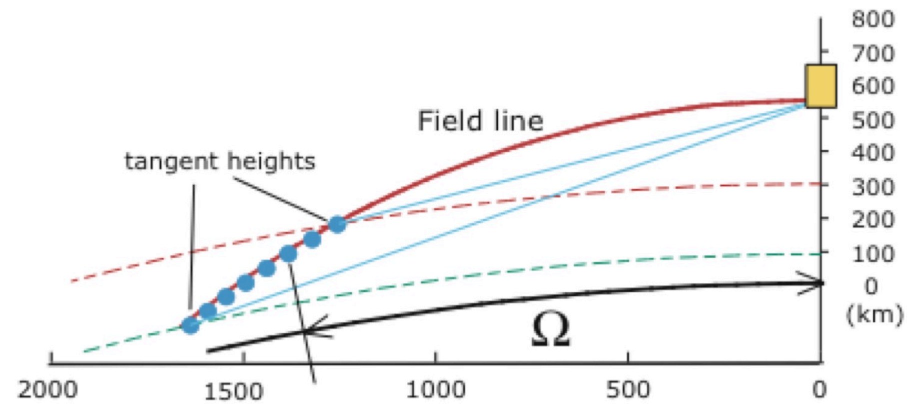
•Green emission



•**Data** shows significant variability compared to **climatology** (HWM14, *Drob et al.*, 2015)

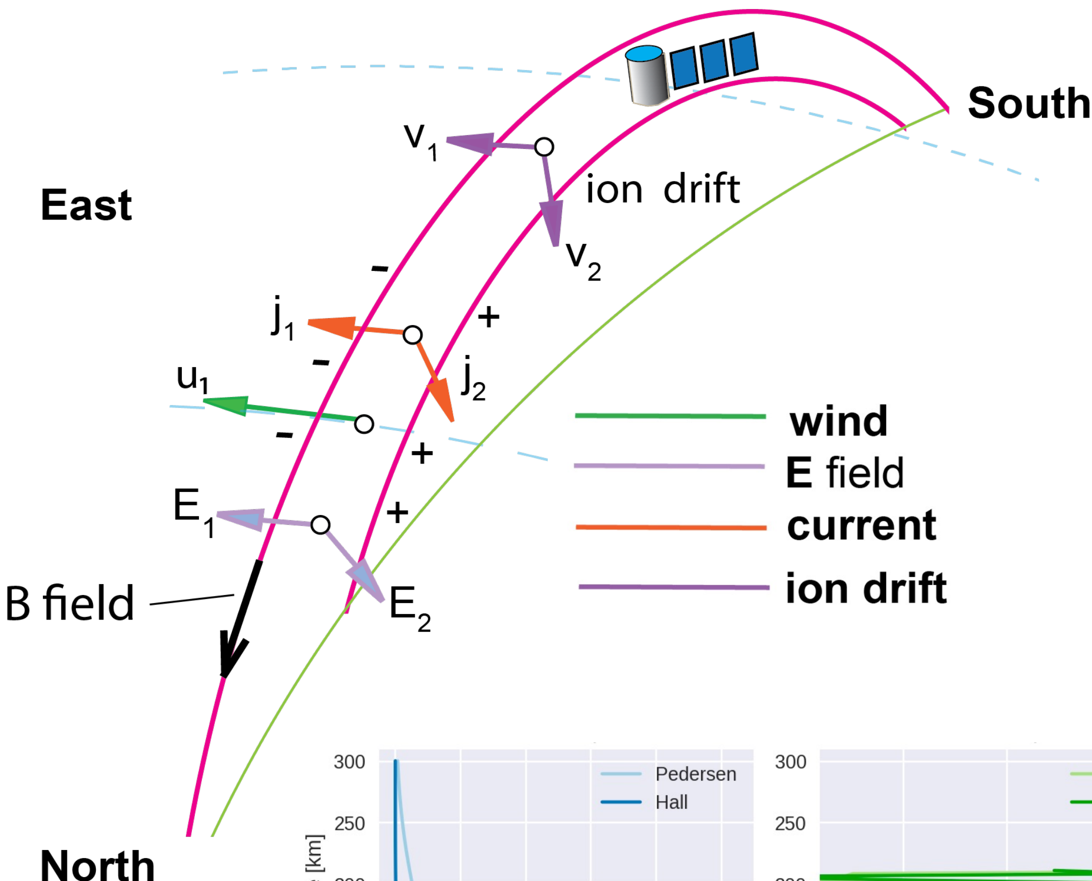
ICON Electrodynamics





- **IVM and MIGHTI** observe the same field line twice per orbit
- One daytime, one nighttime
- 15 daytime passes per day, ~450 per month
- Observe the lower thermospheric wind drivers, and the ionospheric dynamo response, at the same place at nearly the same time (+/- a few minutes)

ICON Electrodynamics



$$\bar{j} = \underline{\sigma} \cdot \left(\bar{E} + \bar{u} \times \bar{B} \right)$$

From Ohm's Law, and where the integrated current along the field line is zero (Ampere's law)

$$\int_S^N \nabla \cdot \bar{j}\, dx_3 = 0$$

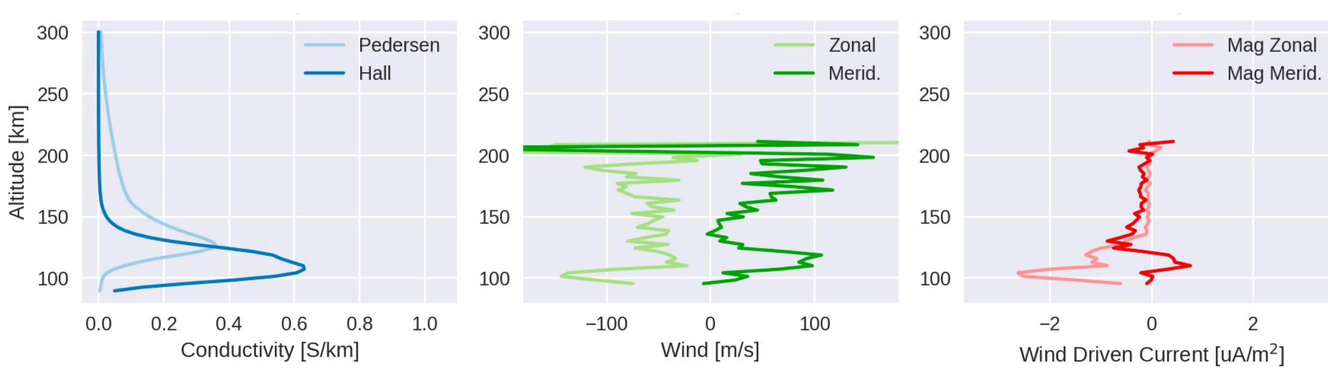
Then with 3 simplifying assumptions

1) Insulating lower footpoints ($j^N_3 = j^S_3 = 0$)
2) Small zonal gradients

$$\left(\frac{\partial \Sigma_P}{\partial x_1} \approx \frac{\partial \Sigma_H}{\partial x_1} \approx 0 \right)$$

3) Zero net meridional current, $J_2 = 0$

one may derive the ExB velocity of the plasma related to the wind driver (next slide)

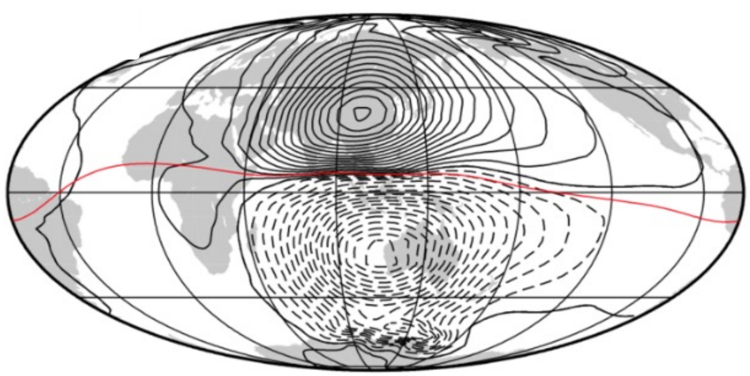


Comparing Winds and Plasma Motion

Predicted plasma drift

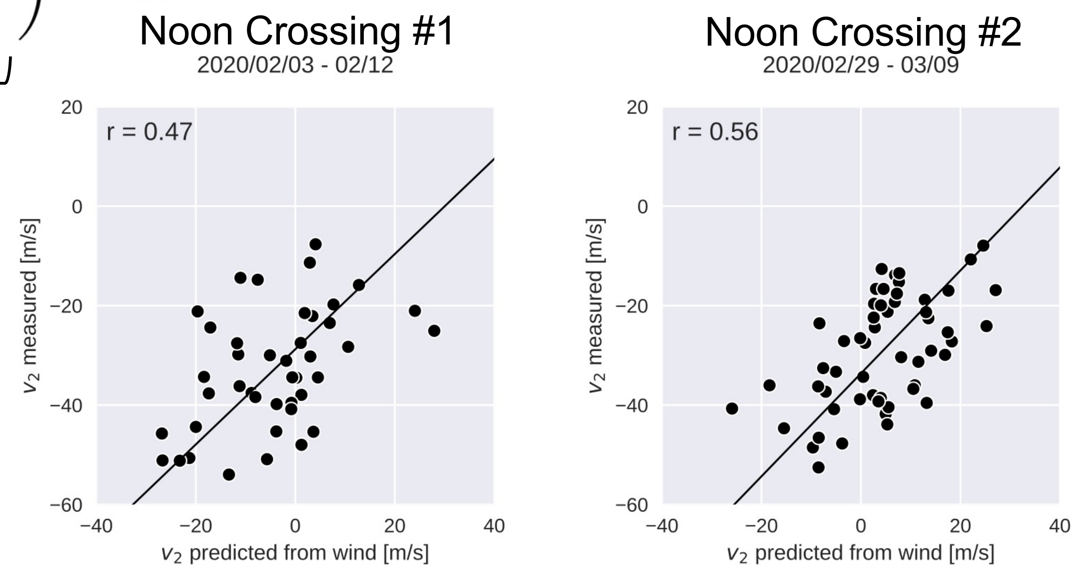
$$v_2 = -\underbrace{\left(\frac{\Sigma_H}{\Sigma_C}U_1^H + \frac{\Sigma_P}{\Sigma_C}U_2^P + \frac{\Sigma_H^2}{\Sigma_C\Sigma_P}U_2^H - \frac{\Sigma_H}{\Sigma_C}U_1^P\right)}_{\text{“Effective wind” includes all 4 conductivity weighted winds}} + C_{ext}$$

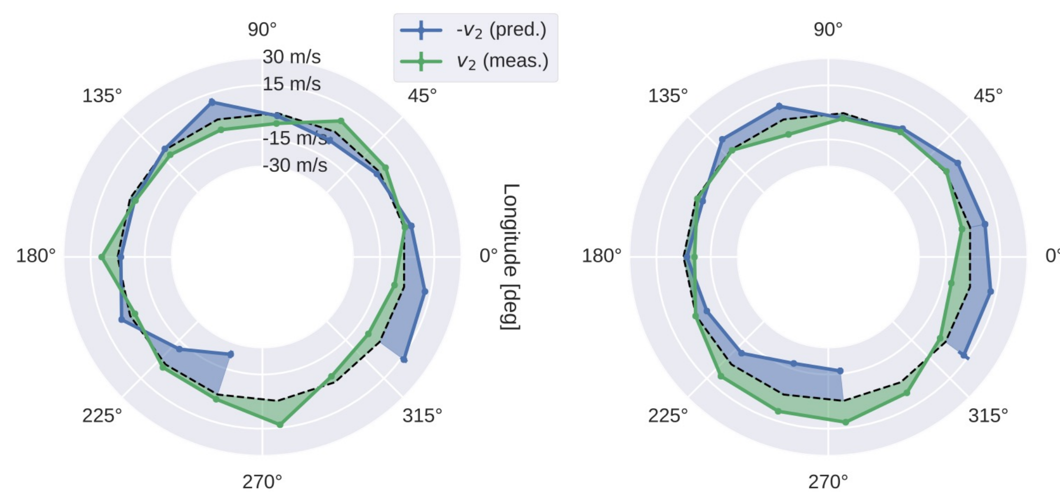
- ❑ Using MSIS and IRI to provide conductances and conductivity weighted winds, predicted plasma drifts can be compared to actual drifts.
- ❑ We select LT from 12 to 14 hours to minimize zonal conductivity gradients.
- ❑ This naturally provides 10 days of data per noon crossing.



•Ionospheric Sq current system

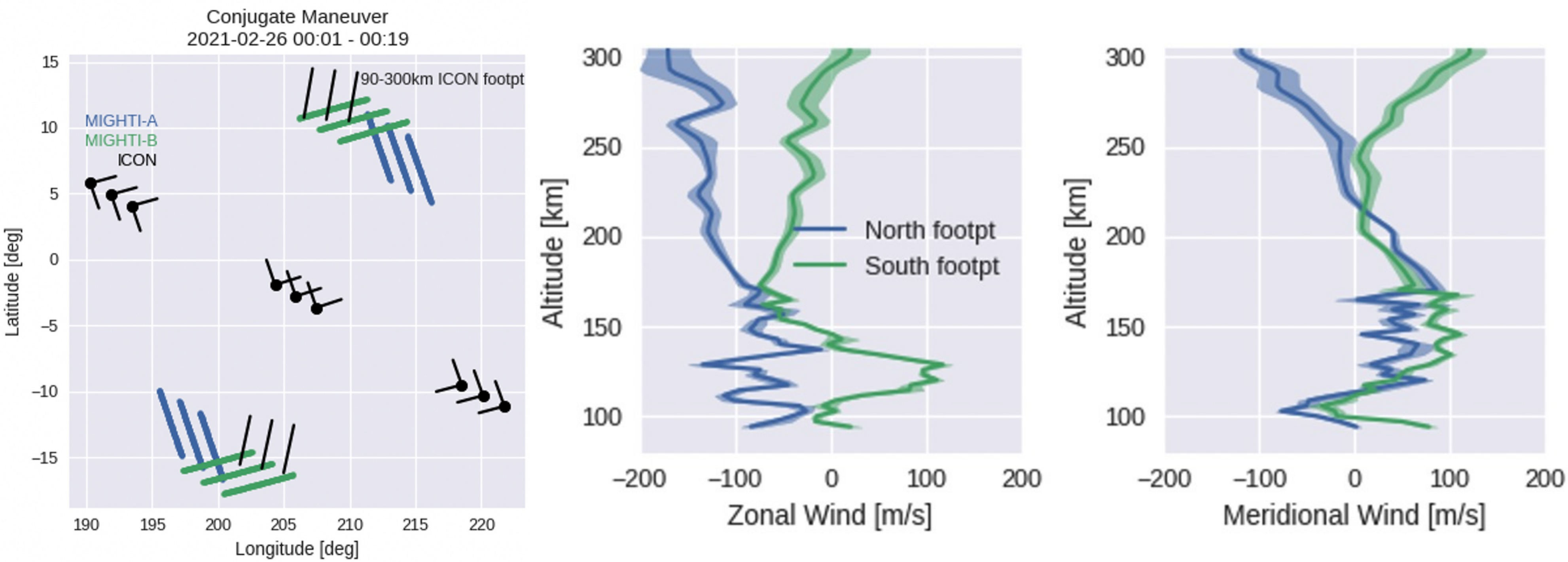
•*Sabaka et al.* [2015]





First results of dynamo investigation

- ❑ ICON regularly finds significant correlations of ~0.5 between predicted and observed drifts.
- ❑ It indicates that the local drivers are always influential but inefficient.
  - Competing effects on same field line (conjugate) or neighboring field lines.
- ❑ Current effort looking at effects from conjugate hemisphere, with dozens of specific observations (example below).



All Level 2 data available at https://icon.ssl.berkeley.edu/