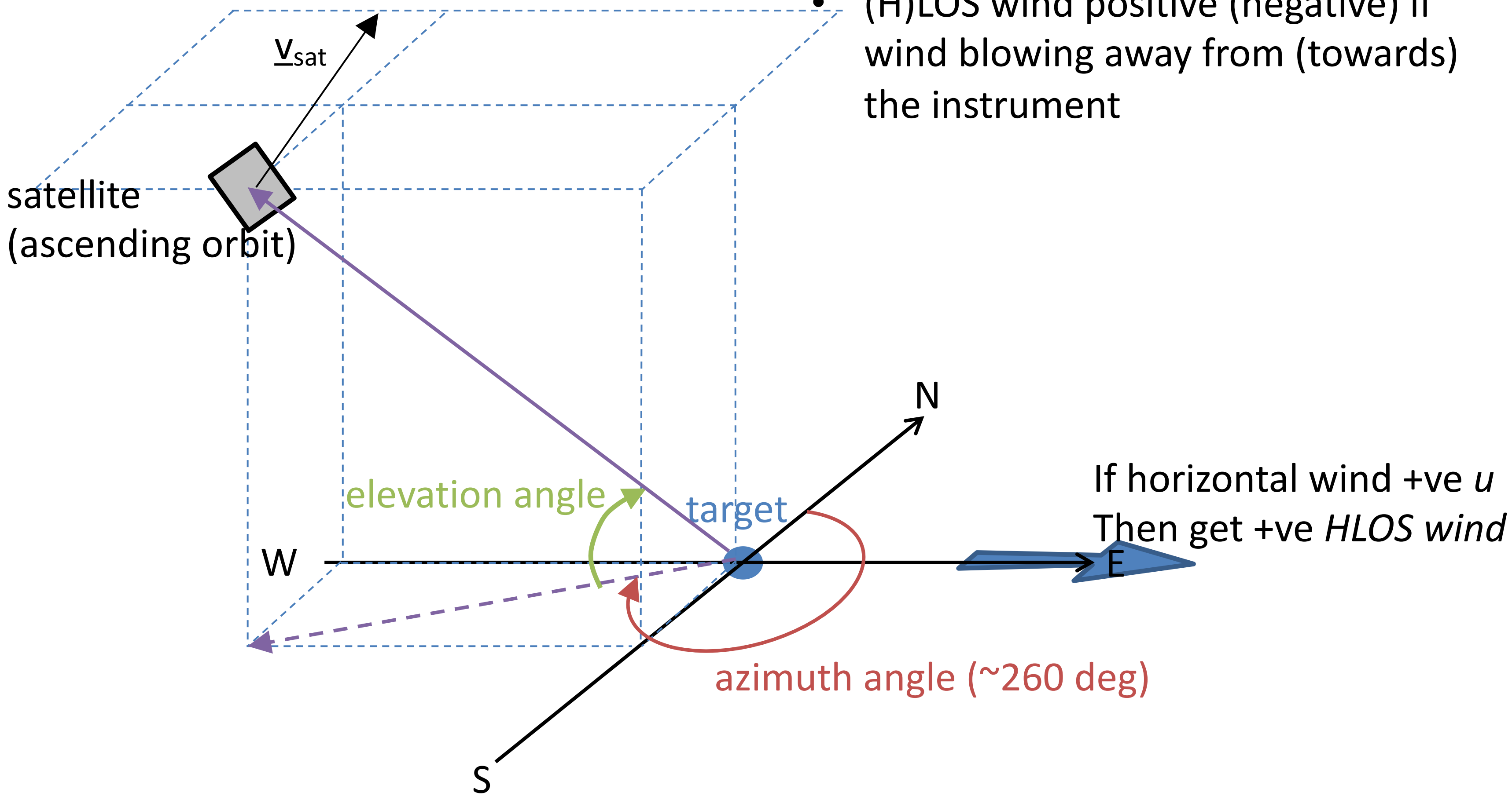
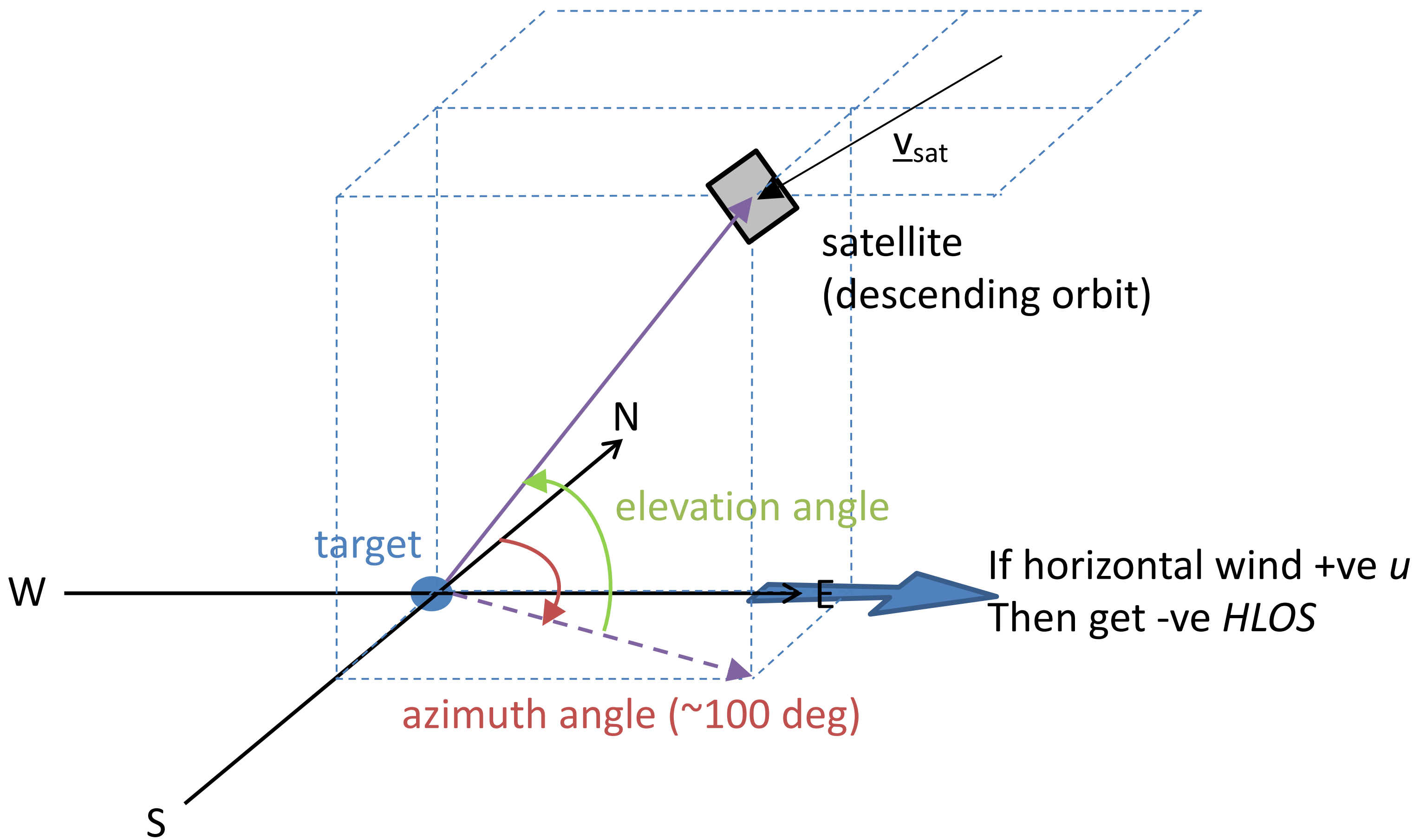
Aeolus geometry

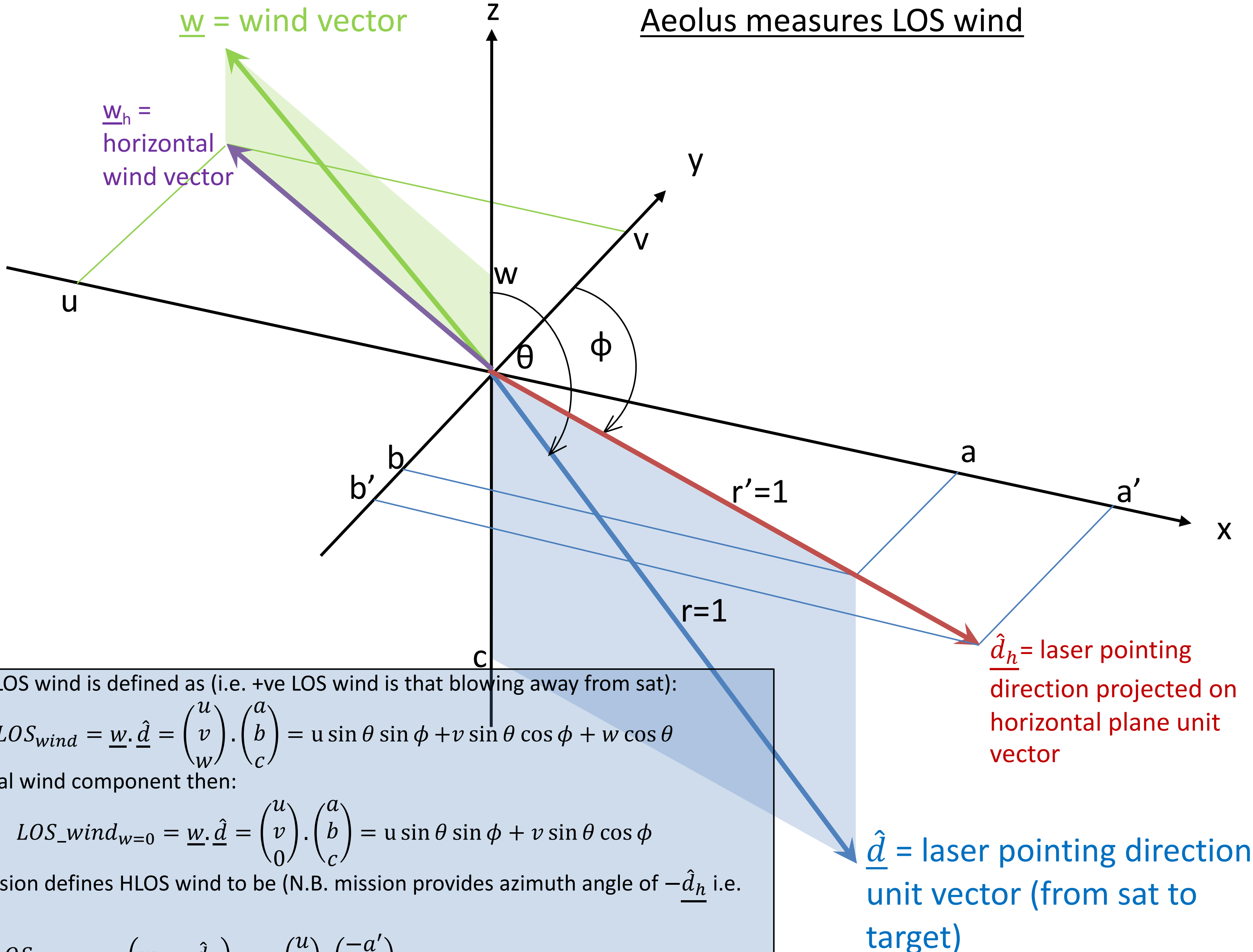
- Azimuth= angle (clockwise from North) of the horizontal projection of the target to satellite pointing vector
- (H)LOS wind positive (negative) if wind blowing away from (towards) the instrument





$\underline{v}_{sat}$
satellite
(descending orbit)
N
elevation angle
target
W
E
If horizontal wind +ve *u*
Then get -ve *HLOS*
azimuth angle (~100 deg)
S

Aeolus measures LOS wind



Complete LOS wind is defined as (i.e. +ve LOS wind is that blowing away from sat):

$$LOS_{wind} = \underline{w}.\underline{\hat{d}} = \begin{pmatrix} u \\ v \\ w \end{pmatrix}.\begin{pmatrix} a \\ b \\ c \end{pmatrix} = \mathrm{u} \sin\theta \sin\phi + v \sin\theta \cos\phi + w \cos\theta$$

If no vertical wind component then:

$$LOS\_wind_{w=0} = \underline{w}.\underline{\hat{d}} = \begin{pmatrix} u \\ v \\ 0 \end{pmatrix}.\begin{pmatrix} a \\ b \\ c \end{pmatrix} = \mathrm{u} \sin\theta \sin\phi + v \sin\theta \cos\phi$$

Aeolus mission defines HLOS wind to be (N.B. mission provides azimuth angle of $-\underline{\hat{d}_h}$ i.e. φ'):

$$HLOS_{wind} = -\left(\underline{w_h}.-\underline{\hat{d}_h}\right) = -\begin{pmatrix} u \\ v \end{pmatrix}.\begin{pmatrix} -a' \\ -b' \end{pmatrix}$$

$$= -\mathrm{u} \sin(\phi + \pi) - v \cos(\phi + \pi) = -u \sin\phi' - v \cos\phi' = \frac{LOS\_wind_{w=0}}{\sin\theta}$$

Propagation of uncertainty in HLOS wind forward model

$$HLOS_{wind} = -u\sin\phi' - v\cos\phi' + w\cot\theta$$

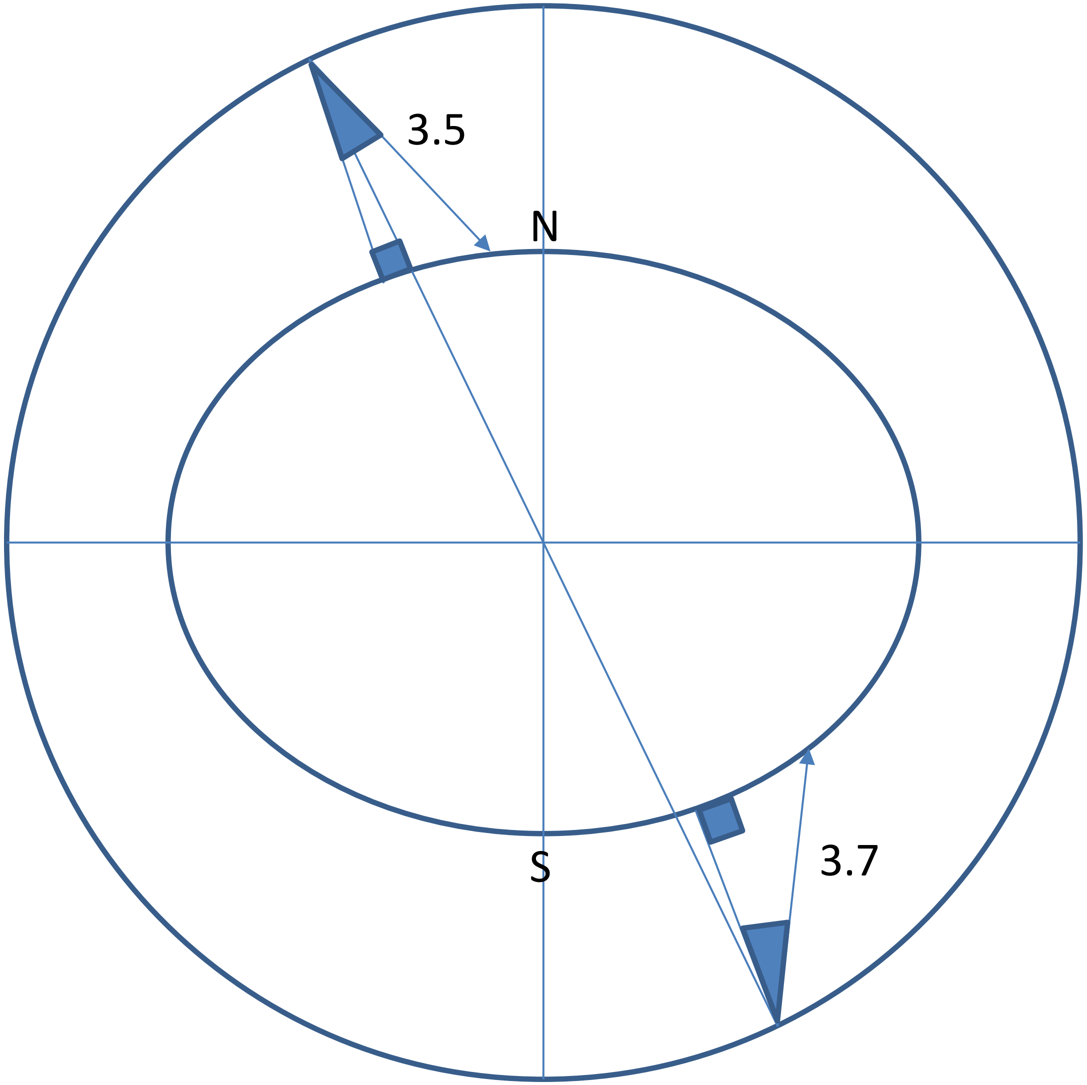
$$\sigma^2_{HLOS_{wind}} = \left|\frac{\partial HLOS_{wind}}{\partial u}\right|^2 \sigma_u^2 + \left|\frac{\partial HLOS_{wind}}{\partial v}\right|^2 \sigma_v^2 + \left|\frac{\partial HLOS_{wind}}{\partial w}\right|^2 \sigma_w^2 + \left|\frac{\partial HLOS_{wind}}{\partial \phi'}\right|^2 \sigma_{\phi'}^2 + \left|\frac{\partial HLOS_{wind}}{\partial \theta}\right|^2 \sigma_\theta^2$$

$$\sigma^2_{HLOS_{wind}} = \sigma_u^2\sin^2\phi' + \sigma_v^2\cos^2\phi' + \sigma_w^2\cot^2\theta + \sigma_{\phi'}^2(u^2\cos^2\phi' + v^2\sin^2\phi' - 2uv\sin\phi'\cos\phi') + \sigma_\theta^2 w^2 cosec^4\,\theta$$

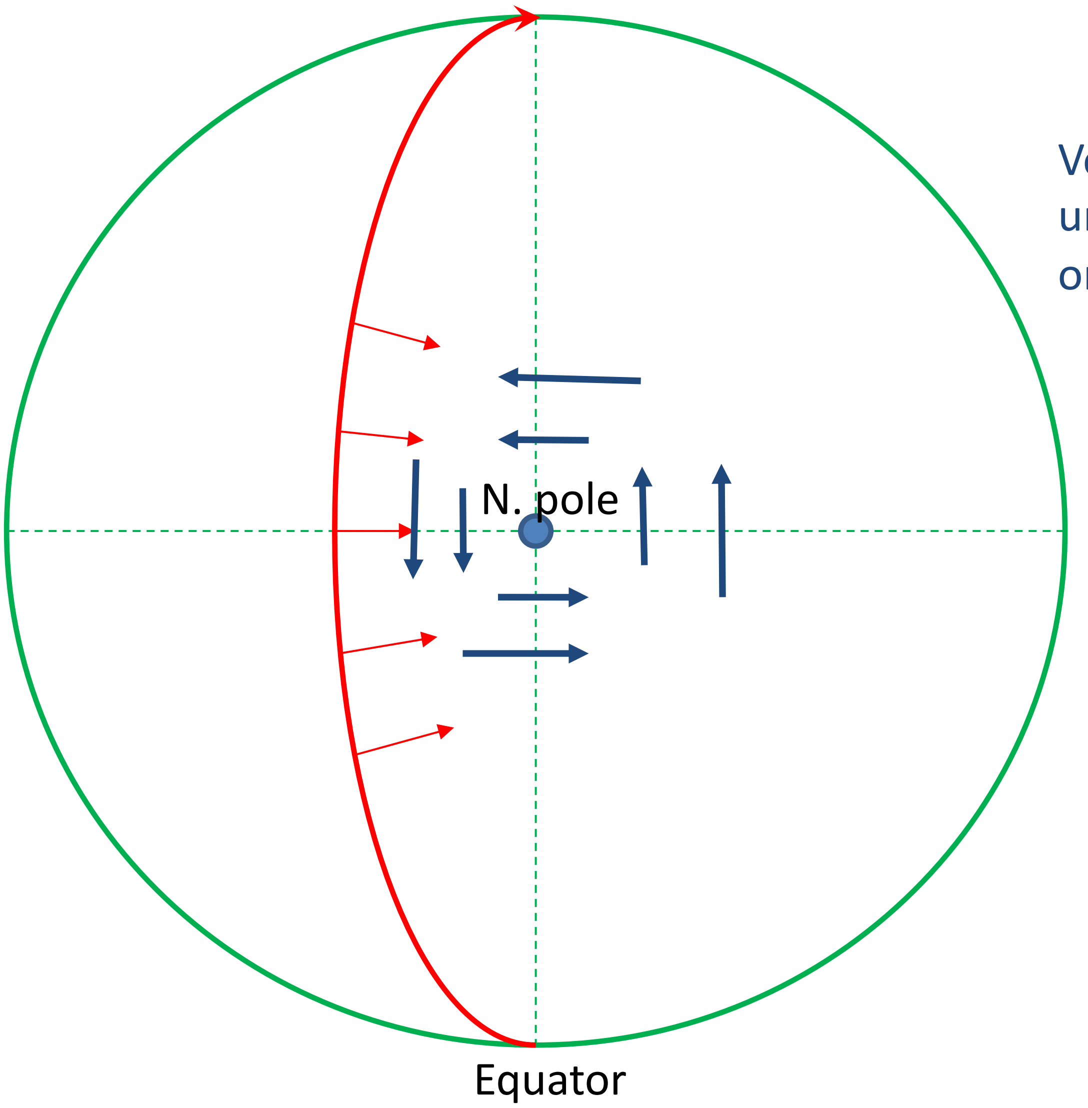
Total differential of HLOS wind forward model

$$dHLOS_{wind} = \frac{\partial HLOS_{wind}}{\partial u}du + \frac{\partial HLOS_{wind}}{\partial v}dv + \frac{\partial HLOS_{wind}}{\partial w}dw + \frac{\partial HLOS_{wind}}{\partial \phi'}d\phi' + \frac{\partial HLOS_{wind}}{\partial \theta}d\theta$$

$$= -du\sin\phi' - dv\cos\phi' + dw\cot\theta + (v\sin\phi' - u\cos\phi')d\phi' + d\theta w\, cosec^2\,\theta$$

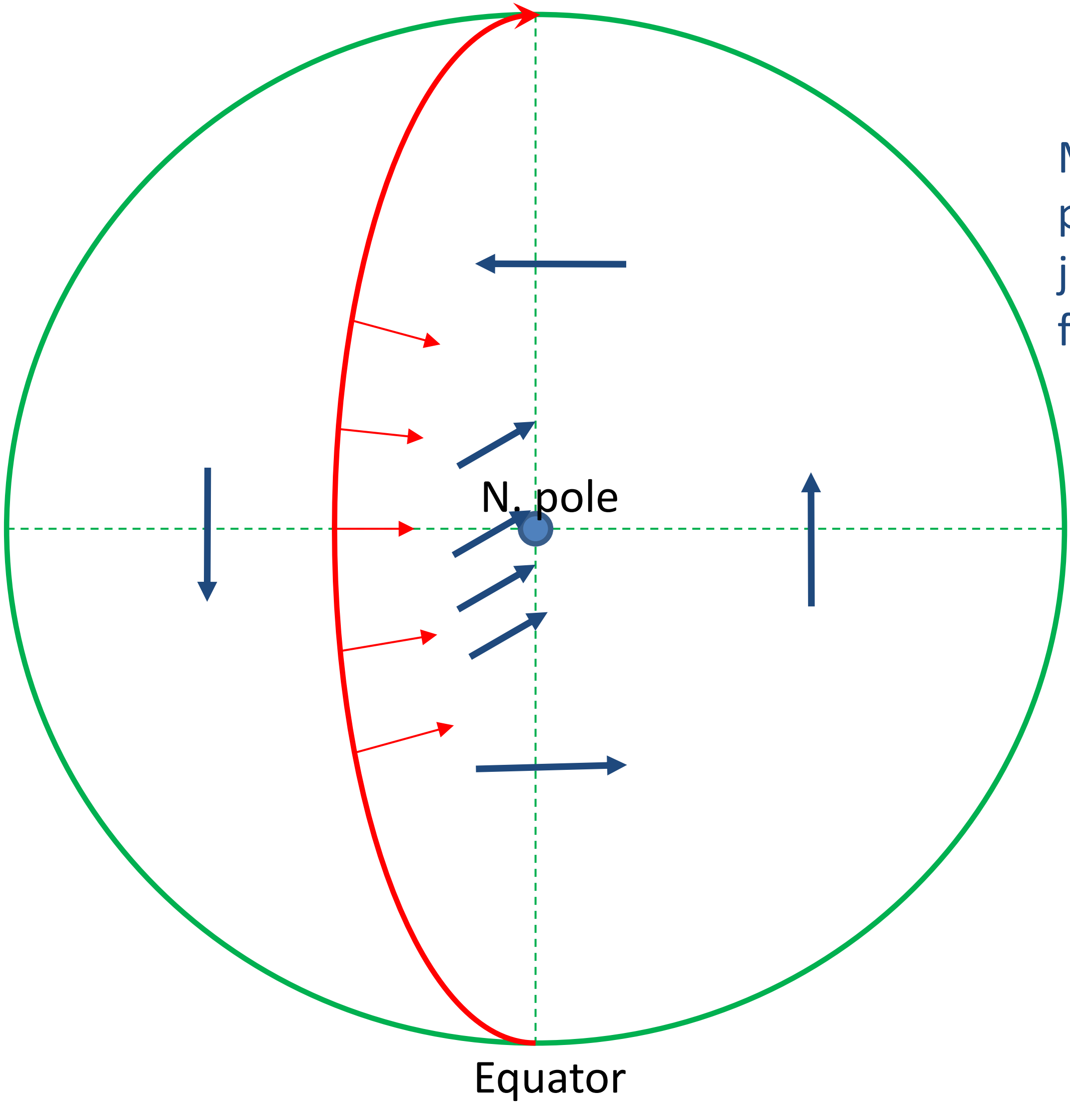

3.5
N
S
3.7

Aeolus orbit and LOS directions



Vector winds for an unrealistic vortex centred on the pole

Aeolus orbit and LOS directions



More realistic wind pattern near poles, and jet streams/polar vortex further south