Total Ionospheric Conductance: Summation of Sources

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$$\Sigma_{Total} = \sqrt{(\Sigma_{EUV}^2 + \Sigma_{Diff.}^2 + \Sigma_{ME}^2)} + \Sigma_{BB}$$

OR

$$\Sigma_{Total} = \sqrt{(\Sigma_{EUV}^2 + \Sigma_{Diff.}^2 + \Sigma_{ME}^2) + \Sigma_{BB}^2}$$

- ***Conductive ionosphere*** acts as load on the complex system of magnetospheric currents to flow.
- Sources of ionospheric conductivity:
  - Solar EUV
  - Particle Precipitation
    - Diffuse (Diff.)
    - Monoenergetic (ME)
    - Broadband (BB)
- Conductance Σ is height integrated conductivity

$$\Sigma = \int_{h1}^{h2} \sigma dh$$

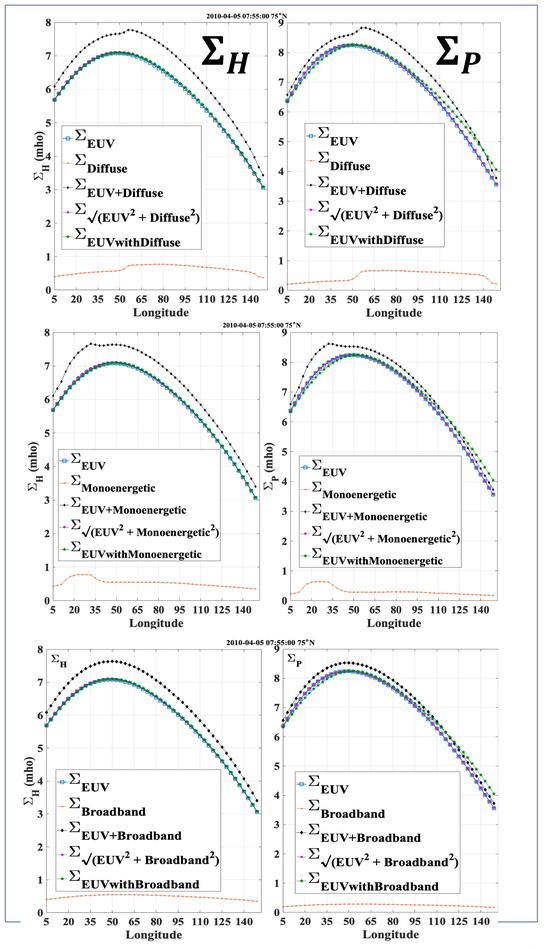
- Empirically, total ionospheric conductance (Hall and Pedersen) is found to be the root sum square of individual conductances
- Presence of less energetic broadband electron precipitation causes ionization in bottom-side F region
- But, can Σ_{BB} be linearly added to total conductance?

Global Ionosphere Thermosphere Model

- Solve ionosphere and thermosphere dynamics
- Physics-based Σ_H *and* Σ_P from Φ, ave. energy and E Flux

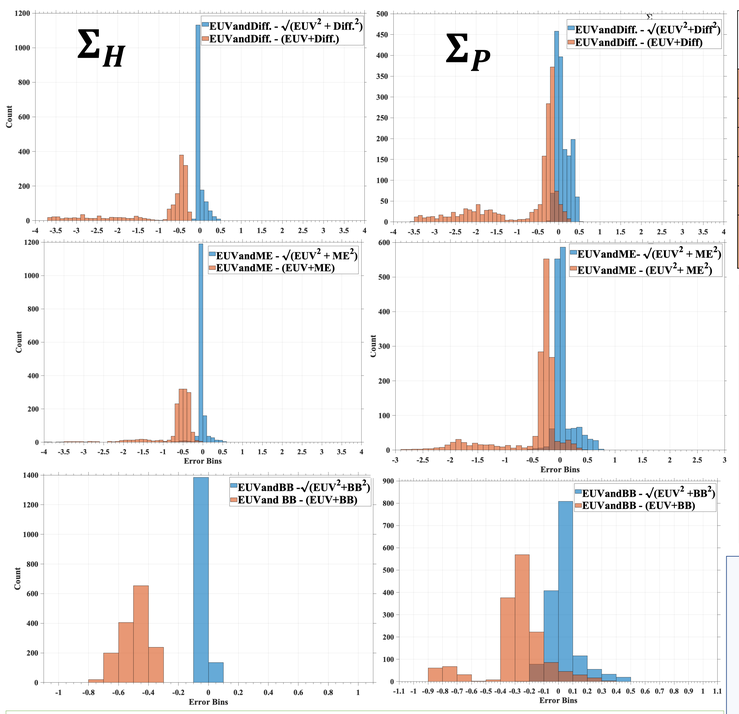
❑ GITM runs - **5 April 2010**

1.EUV 2.Particle Precipitations 3.EUV&Diff. 4.EUV&ME 5.EUV&BB

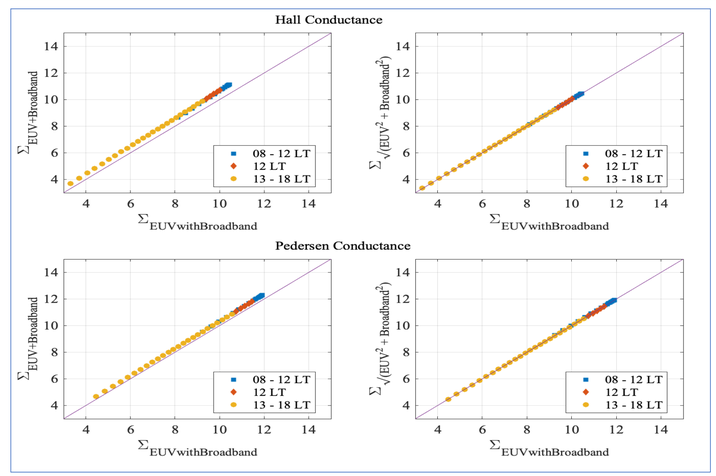


? **Clearly, Σ_{Total} is not a linear sum.**

? **How well does the vector sum represent Σ_{Total}?**



Histograms showing errors of both summations for all latitudes from 60-90^O



Linear and vector summation at 75^O N

Σ_H	Linear Sum			Vector Sum		
	Diff.	ME	BB	Diff.	ME	BB
RMSE	1.4495	0.9285	0.502	0.0897	0.1235	0.0259
ME	1.0510	0.7004	0.4921	-0.0098	0.0188	0.0220
$Std_{.Diff}$	0.7742	0.2360	0.0811	-0.0478	0.0049	0.0010
$Std_{.ratio}$	1.3476	1.1186	1.0410	0.9785	1.0025	1.0005
R	0.9702	0.9643	0.9998	0.9994	0.9981	1.0000
Fractional Error	23.59	15.635	8.5393	1.46	2.0792	0.4418

Σ_P	Linear Sum			Vector Sum		
	Diff.	ME	BB	Diff.	ME	BB
RMSE	1.2602	0.7377	0.3491	0.1866	0.1827	0.1076
ME	0.8066	0.4703	0.2810	-1.0751	-1.1113	-1.1019
$Std_{.Diff}$	0.7360	0.1277	0.0088	-0.0106	0.0170	0.0328
$Std_{.ratio}$	1.3263	1.0625	1.0043	0.9826	1.0083	1.0161
R	0.9706	0.9654	0.9949	0.9976	0.9965	0.9989
Fractional Error	17.48	10.4368	5.0007	2.5897	2.5853	1.5414

Calculated ionization rates due to precipitating, isotropic, monoenergetic proton fluxes with an energy flux of 0.1erg cm^{-2}s^{-1} (Schunk and Nagy, 2000)

Results

- Conductances resulting from different processes **do not add linearly**
- Vector addition shows lesser error
- Thus, **Σ_{Total} is the vector sum of ALL the sources.**

$$\Sigma_{Total} = \sqrt{(\Sigma_{EUV}^2 + \Sigma_{Diff.}^2 + \Sigma_{ME}^2 + \Sigma_{BB}^2)}$$

References:

Wallis&Budzinski, 1981; *Zhang et al.* JGR, 2015
Mukhopadyay et al., JGR 2022

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