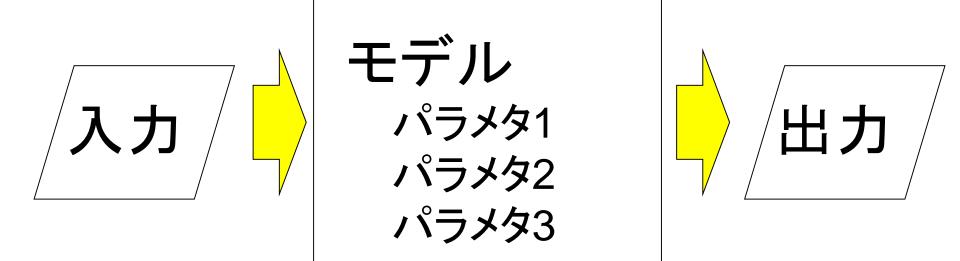
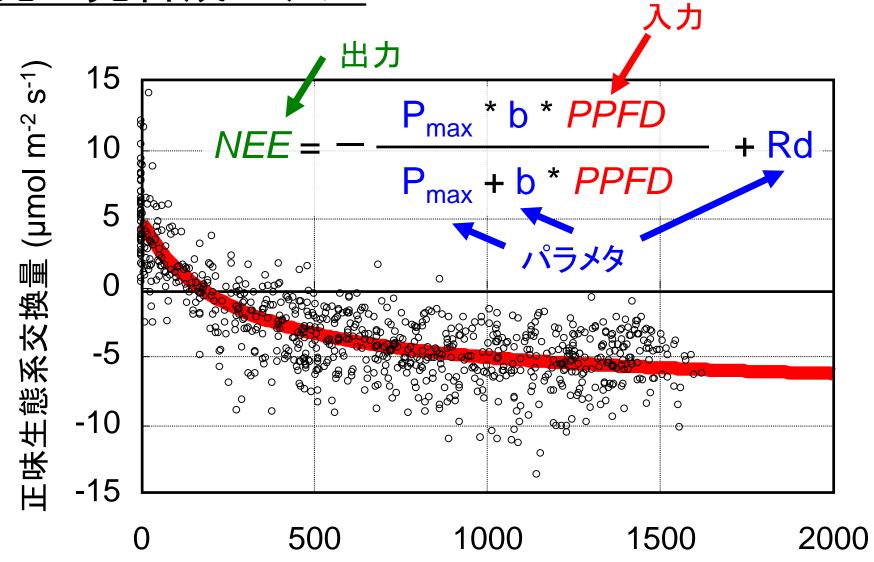
生態系モデリング

モデル

対象とする現象や素過程を数式等で模したもの

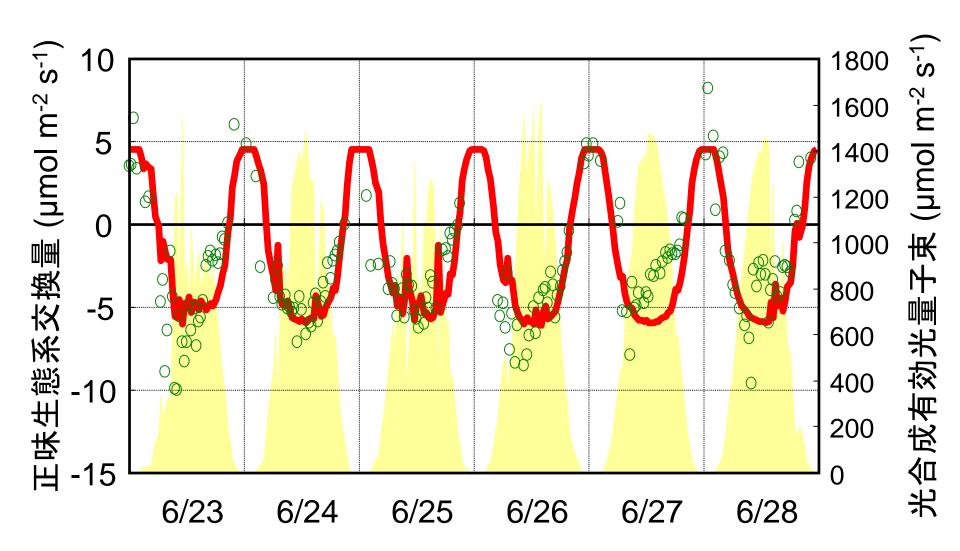


光一光合成モデル



光合成有効光量子束 (μmol m⁻² s⁻¹)

光一光合成モデル



データの診断 (diagnosing)

予測 (prediction)

補間 (interpolation)

モデルの種類

経験モデル

統計モデル、人工知能、機械学習

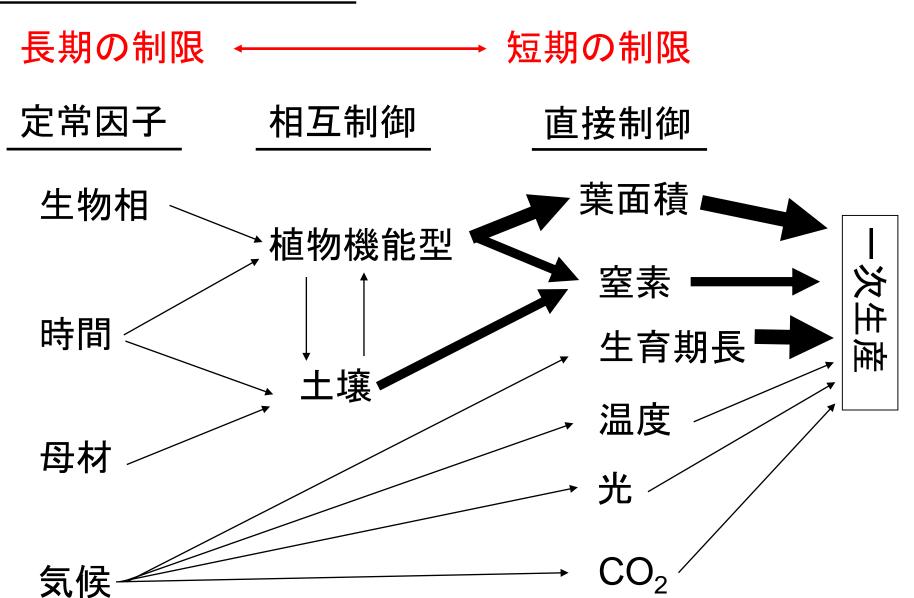
プロセス・モデル

流体モデル、生態系モデル、気候モデル

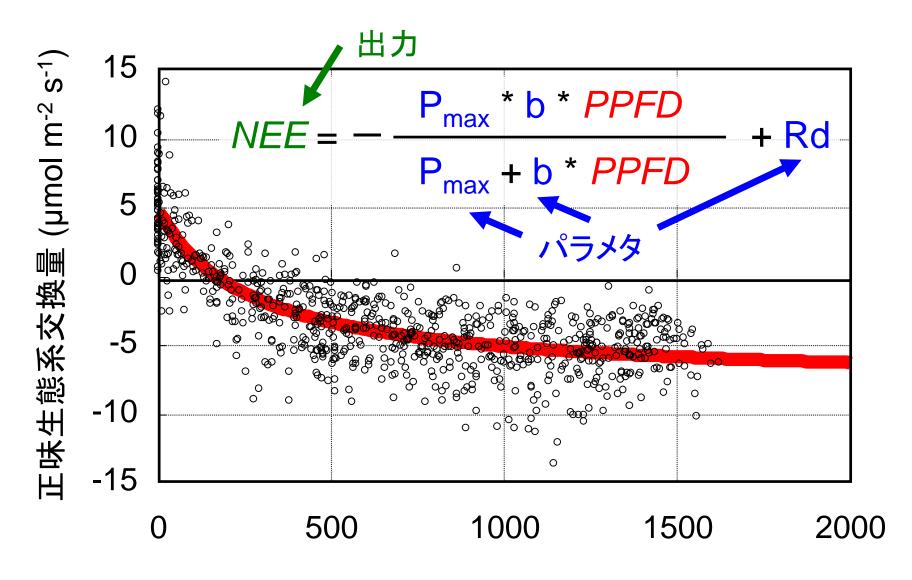
コンセプト・モデル

コンセプト・モデル

(Chapin et al., 2002)



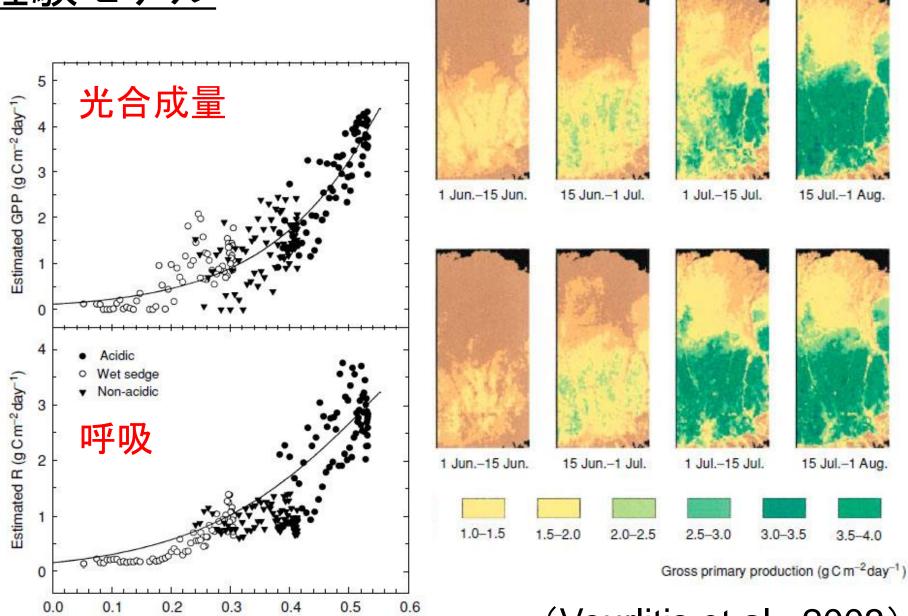
経験モデル



光合成有効光量子束 (μmol m⁻² s⁻¹)

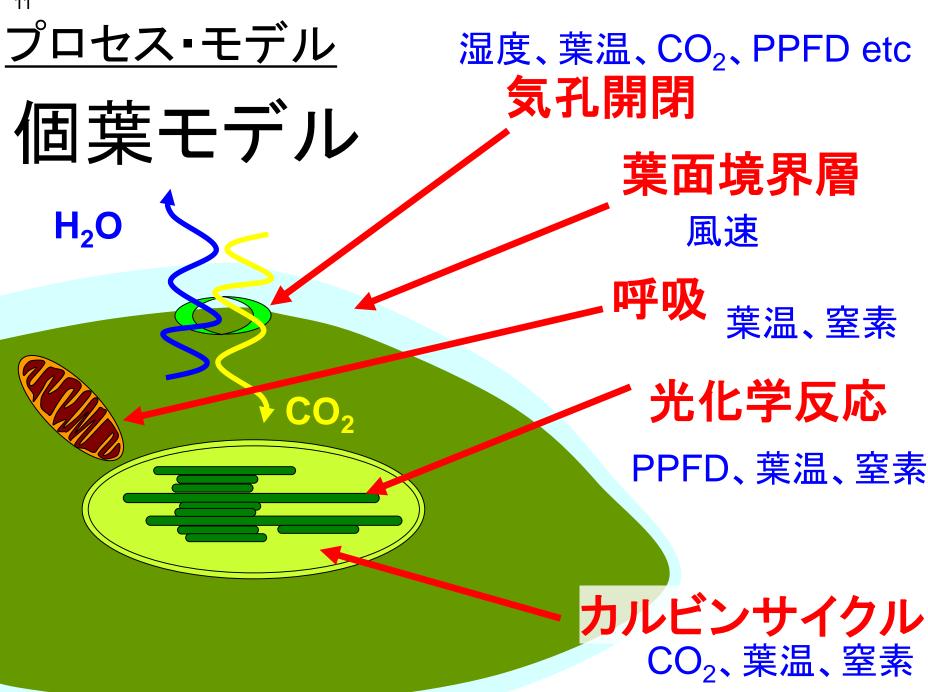
経験モデル

NDVI



(Vourlitis et al., 2003)

熱収支式



12

<u>プロセス・モデル</u>

光合成モデル A = min(W_c, W_i)

カルビンサイクル

光化学反応

$$W_{j} = \frac{J}{4 + 8 p(\Gamma^{*}) p(C_{C})}$$
CO₂補償点

```
13
```

個葉モデル (結合モデル)

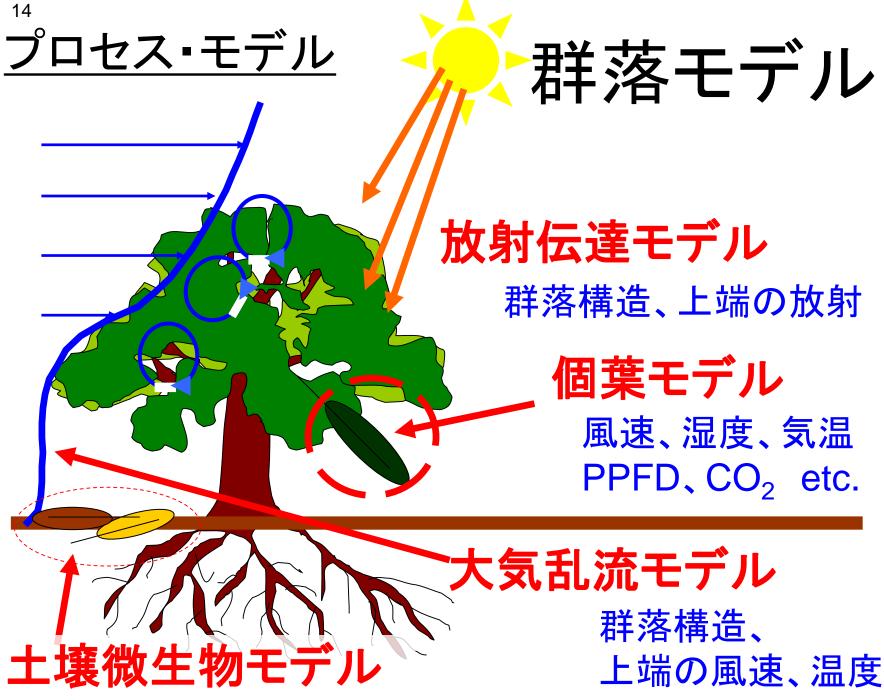
気孔コンダクタンスモデル

葉面境界層モデル
葉面熱収支モデル

呼吸モデル

光合成モデル 光化学反応 カルビンサイクル





大気乱流モデル

$$\frac{\partial \overline{w'c'}}{\partial t} = 0 = \frac{\partial}{\partial z} \left[2e\lambda_1 \frac{\partial \overline{w'c'}}{\partial z} \right] - \overline{w'^2} \frac{\partial \overline{c}}{\partial z} - \frac{e}{3\lambda_4} \overline{w'c'}$$

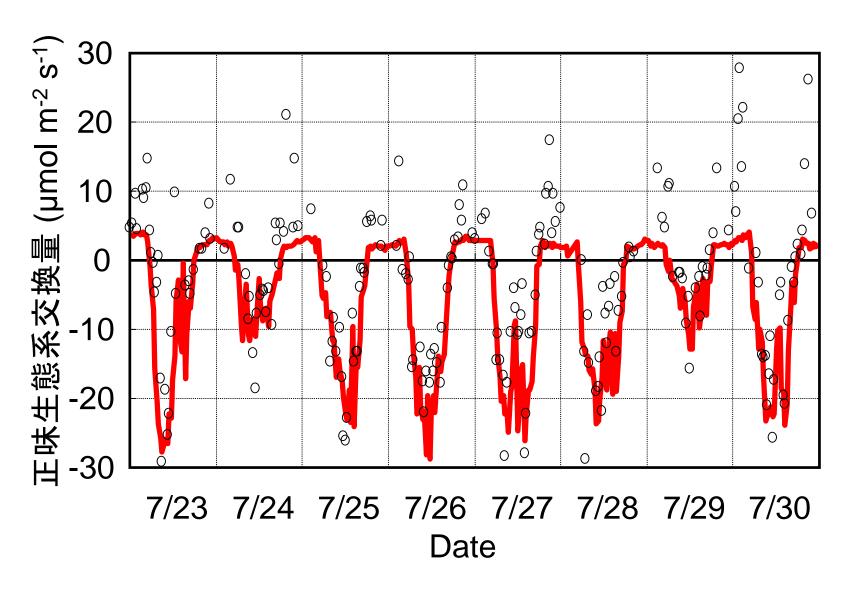
保存則

$$\frac{\partial \overline{c}}{\partial t} = 0 = -\frac{\partial \overline{w'c'}}{\partial z} + S_c$$

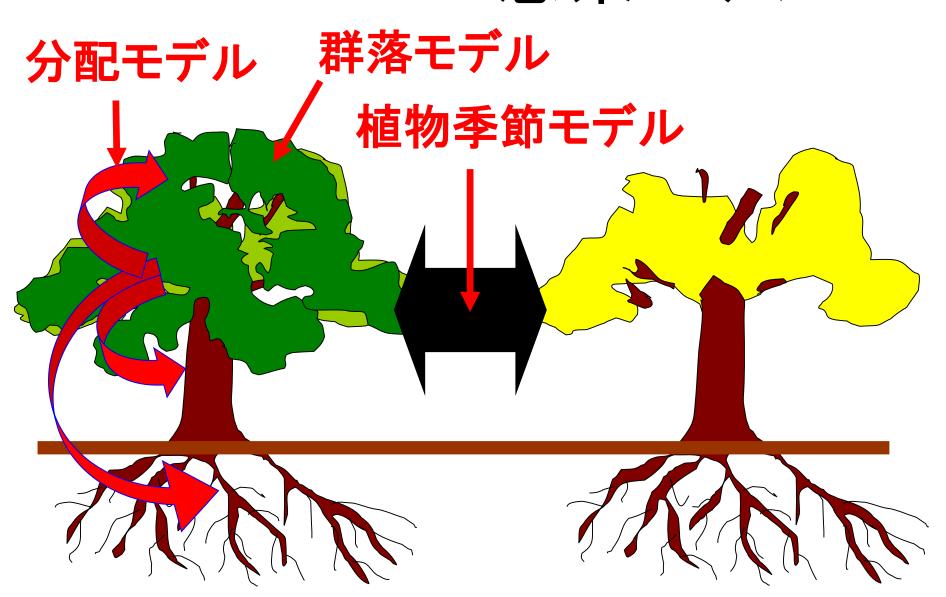
抵抗モデル

$$S_c = aC_c \overline{u} \left(c_L - \overline{c} \right)$$

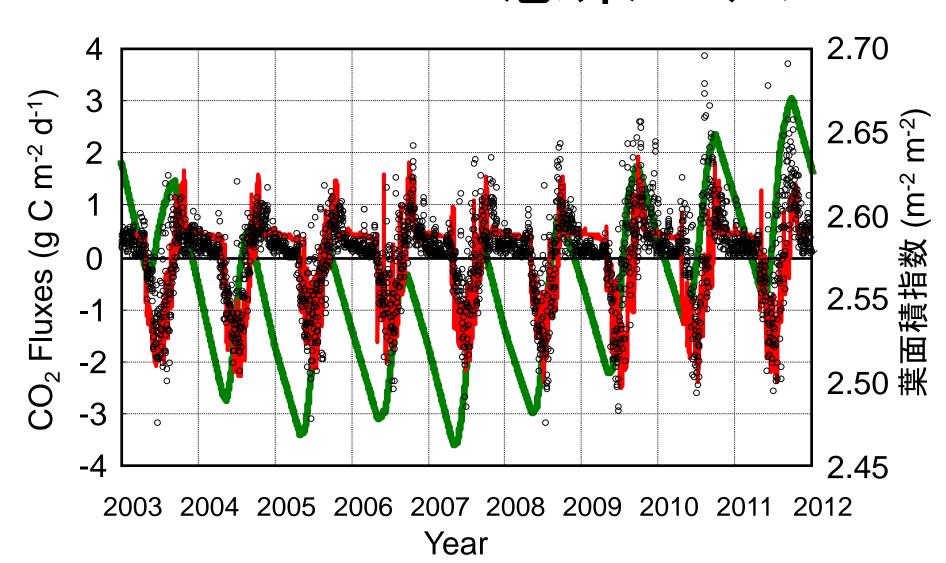
群落多層モデル



生態系モデル

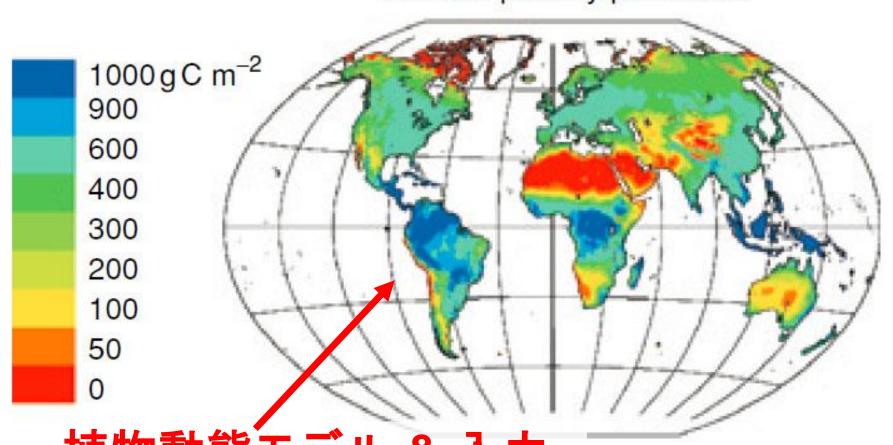


生態系モデル



生態系モデル

LPJ Net primary production



植物動態モデル&入力(遷移や地理的分布)

(Sitch et al., 2003)

モデルの種類と利点・欠点

シンプル

複雜

経験モデル

内挿時はあたりやすい外挿時は精度悪い。



プロセスモデル

正しく考慮されていれば、 外挿もある程度、可能?

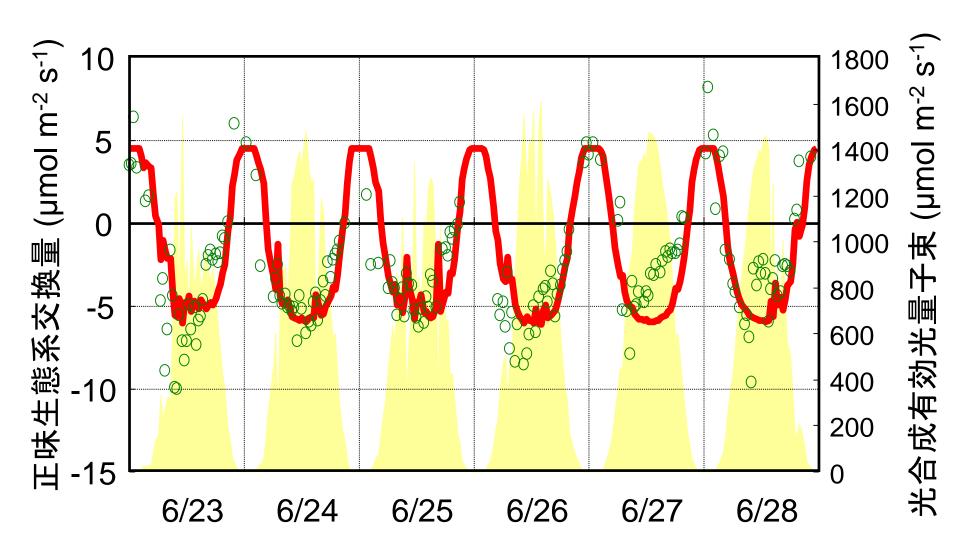
予測に不向き

調整パラメタがない 或いは少ない。

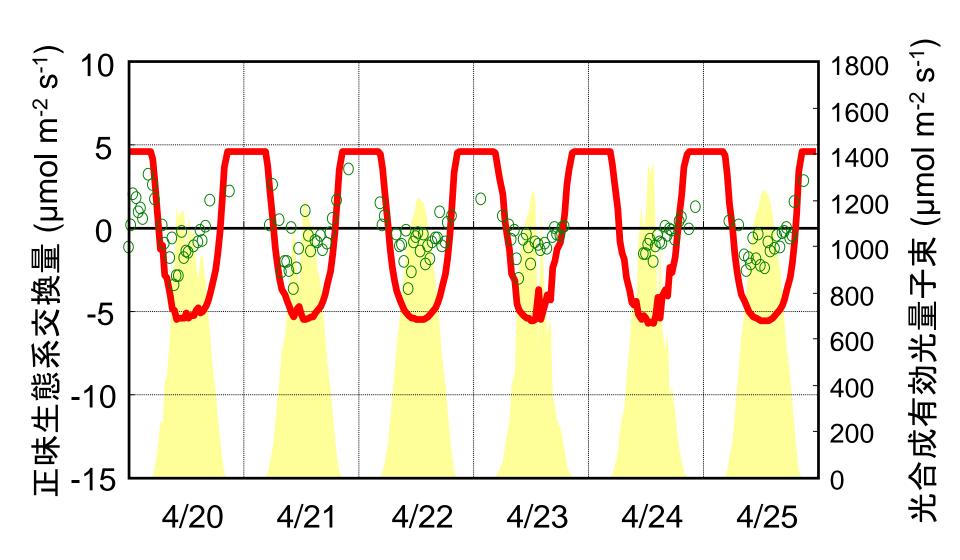


パラメタが多く、 決まらないことがある。

内挿 一経験式が成り立つ場合



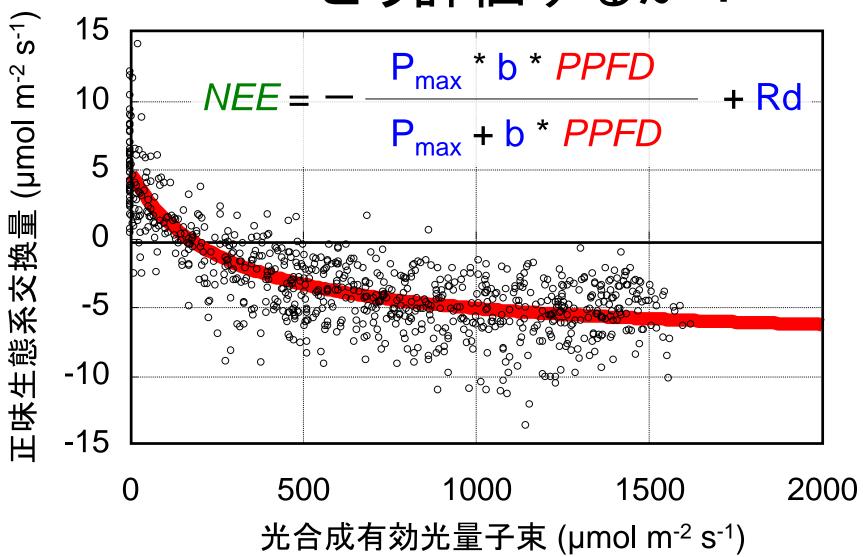
経験式が成り立たない場合

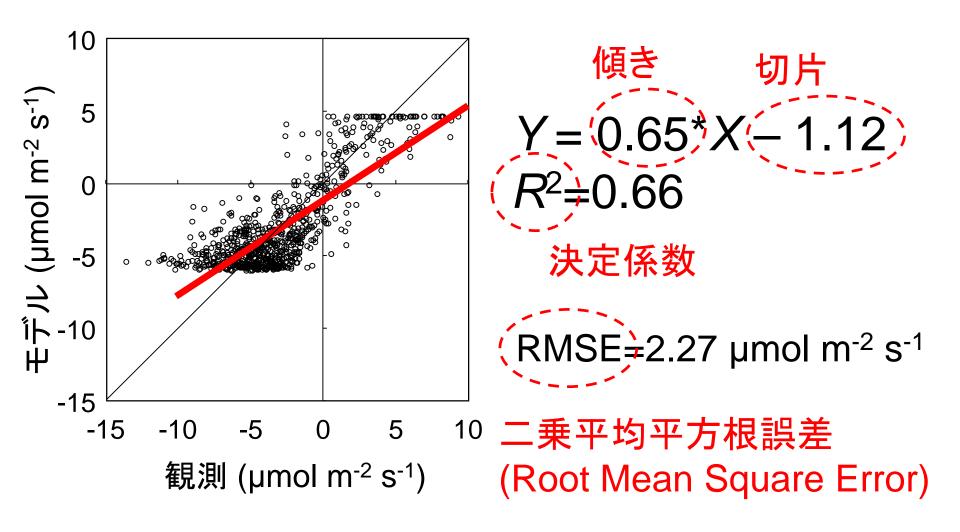


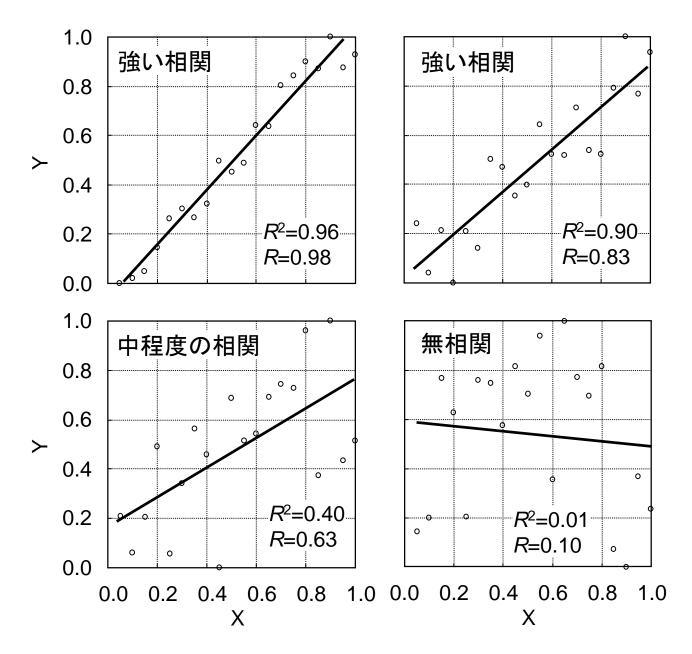
プロセスモデルのパラメタ

```
C3 grass +
2 0
3 0
4 1
5 0
6 0
7 364
                  (flag)
                              = WOODY
                                                   0 = NON-WOODY ↓
                  (flag)
                              = EVERGREEN
                                                   0 = DECIDUOUS +
                                                   0 = C4 PSN +
                  (flag)
                              = C3 PSN
                  (flag)
                            1 = MODEL PHENOLOGY
                                                   0 = USER-SPECIFIED PHENOLOGY *
                            yearday to start new growth (when phenology flag = 0).
                  (yday)
                  (yday)
                            yearday to end litterfall (when phenology flag = 0) .
   1.0
                            transfer growth period as fraction of growing season↓
                  (prop.)
 9 1.0
                  (prop.)
                            litterfall as fraction of growing season.
10 1.0
                  (1/yr)
                            annual leaf and fine root turnover fraction↓
11 0.00
                *(1/yr)
                            annual live wood turnover fraction↓
12 0.1
                  (1/yr)
                            annual whole-plant mortality fraction (herbivory)↓
13 0.1
                  (1/yr)
                            annual fire mortality fraction .
14 2.0
15 0.0
                  (ratio)
                            (ALLOCATION) new fine root C : new leaf C↓
                 *(ratio)
                            (ALLOCATION) new stem C : new leaf C↓
16 0.0
                 *(ratio)
                            (ALLOCATION) new live wood C : new total wood C↓
17 0.0
                *(ratio)
                            (ALLOCATION) new croot C : new stem C↓
18 0.5
                  (prop.)
                            (ALLOCATION) current growth proportion +
19 24.0
                  (kgC/kgN) C:N of leaves↓
  49.0
20
                  (kgC/kgN) C:N of leaf litter, after retranslocation↓
  42.0
                  (kgC/kgN) C:N of fine roots .
22 0.0
                 *(kgC/kgN) C:N of live wood *
23 0.0
                 *(kgC/kgN) C:N of dead wood*
24 0.39
                  (DIM)
                            leaf litter labile proportion↓
25 0.44
                  (DIM)
                            leaf litter cellulose proportion↓
  0.17
                            leaf litter lignin proportion↓
                  (DIM)
27 0.30
                  (DIM)
                            fine root labile proportion↓
  0.45
                  (DIM)
                            fine root cellulose proportion↓
29 0.25
                  (DIM)
                            fine root lignin proportion↓
30 0.75
                            dead wood cellulose proportion +
                 *(DIM)
31 0.25
                 *(DIM)
                            dead wood lignin proportion↓
32 0.021
                  (1/LAI/d)
                            canopy water interception coefficient 🕹
33 0.6
                  (DIM)
                            canopy light extinction coefficient .
34 2.0
                  (DIM)
                            all-sided to projected leaf area ratio↓
  45.0
35
                  (m2/kgC)
                            canopy average specific leaf area (projected area basis) +
36
  2.0
                  (DIM)
                            ratio of shaded SLA:sunlit SLA.
37 0.15
                  (DIM)
                            fraction of leaf N in Rubisco↓
38 0.005
                  (m/s)
                            maximum stomatal conductance (projected area basis) 🗸
39 0.00001
                  (m/s)
                            cuticular conductance (projected area basis) 🔻
40 0.04
                  (m/s)
                            boundary layer conductance (projected area basis) 🔻
41 -0.6
                  (MPa)
                            leaf water potential: start of conductance reduction↓
  -2.3
42
                  (MPa)
                            leaf water potential: complete conductance reduction↓
43 930.0
                  (Pa)
                            vapor pressure deficit: start of conductance reduction↓
44 4100.0
                  (Pa)
                            vapor pressure deficit: complete conductance reduction↓
```

どう評価するか?







回帰式の傾き、切片

変動量の強さ 平均的なバイアス

相関係数、決定係数、有意水準

共変動の強さ

RMSE

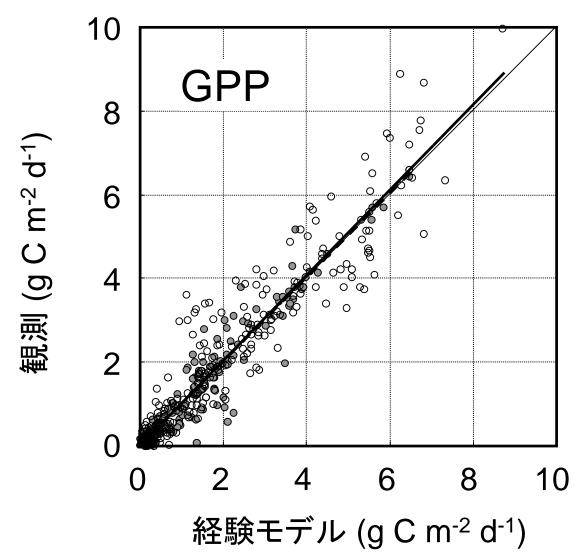
予測精度の悪さ

ME (mean error)

平均的な差 (バイアス)

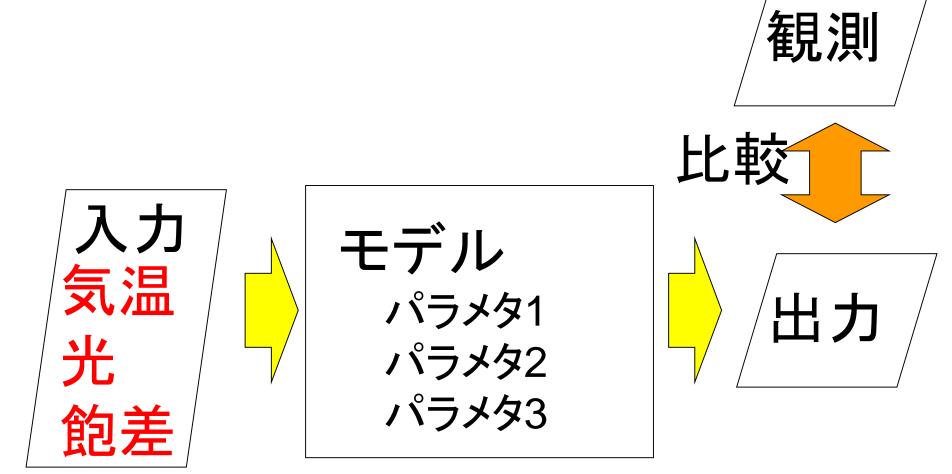
X² 適合度

Training: y = 1.01x + 0.06 R^2 =0.91, p < 0.05 RMSE=0.80 g C m⁻² d⁻¹



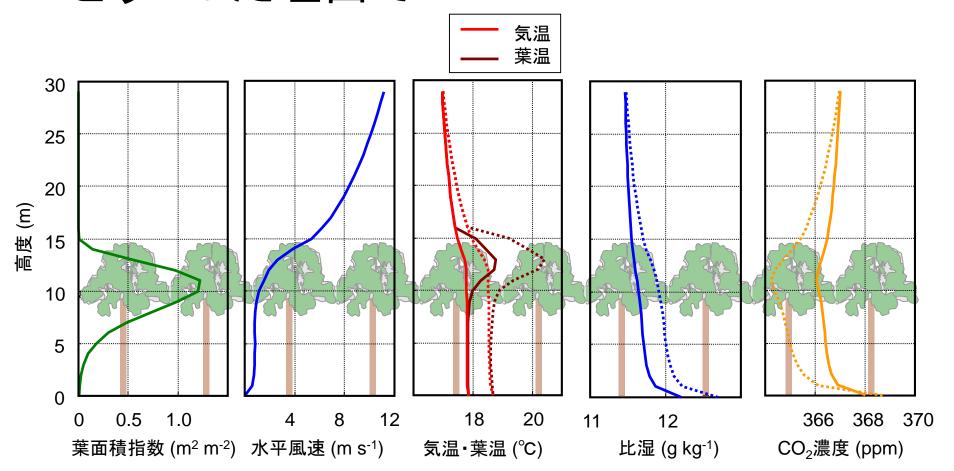
(Ueyama et al., 2013)

アトリビューション分析・要因分析



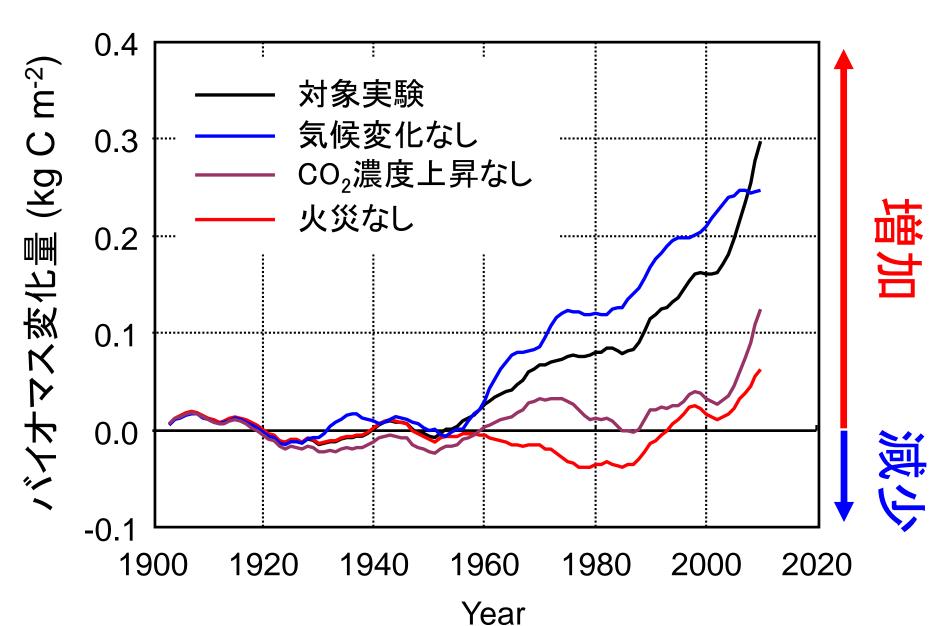
微気象 -micrometeorology-

風速が2倍になったら? どういった理由で?

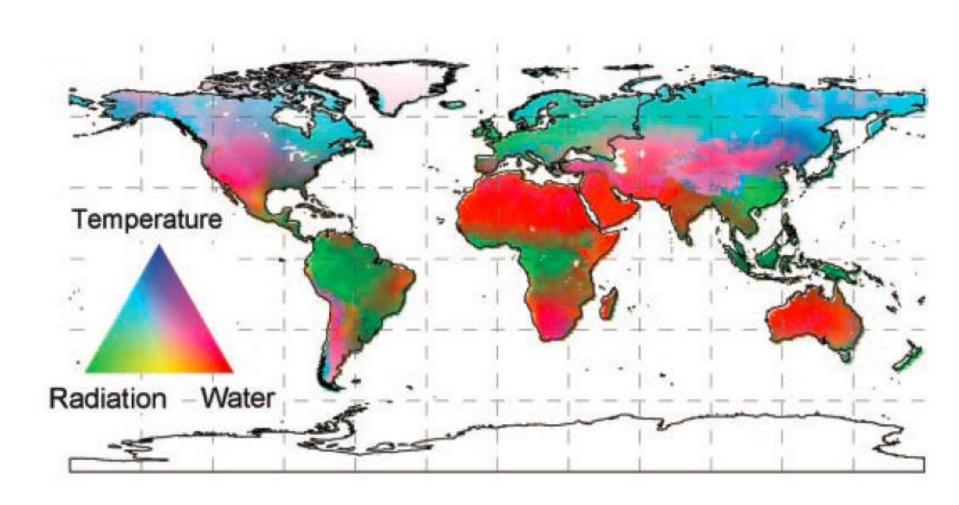


要因分析

気候変化、CO。濃度上昇、火災



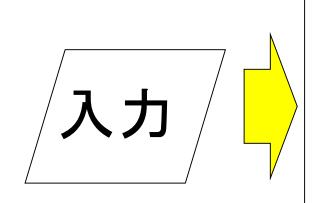
要因分析



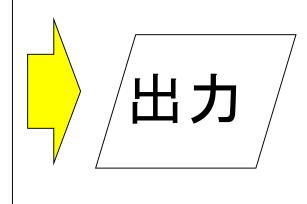
群落光合成速度に影響を及ぼす要因

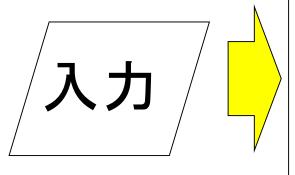
(Nemani et al., 2003)

モデルの最適化 (パラメタの決定)

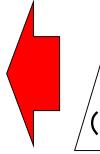


モデル パラメタ1 パラメタ2 パラメタ3

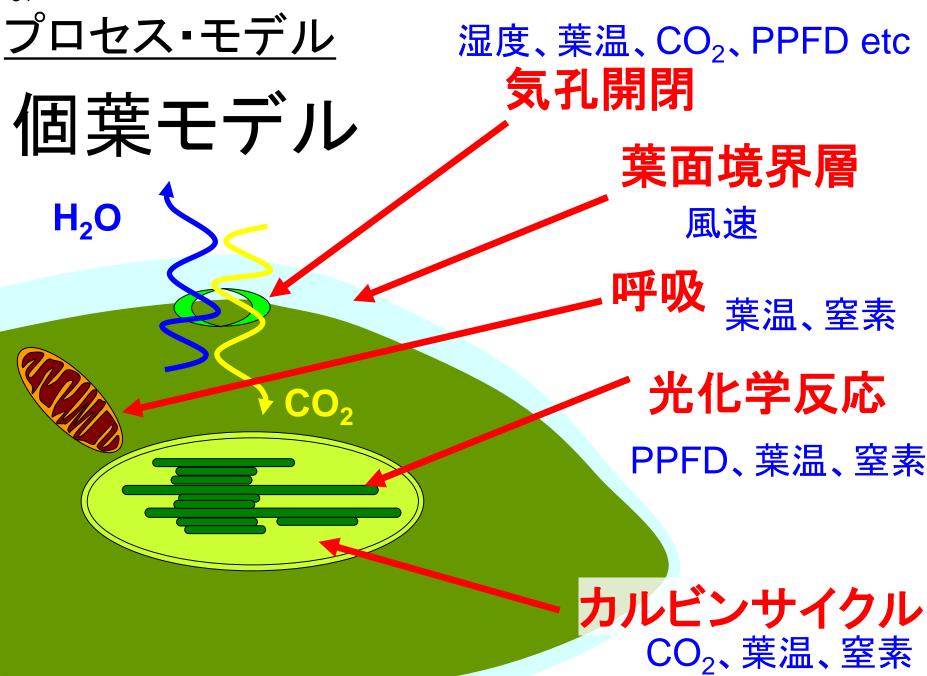




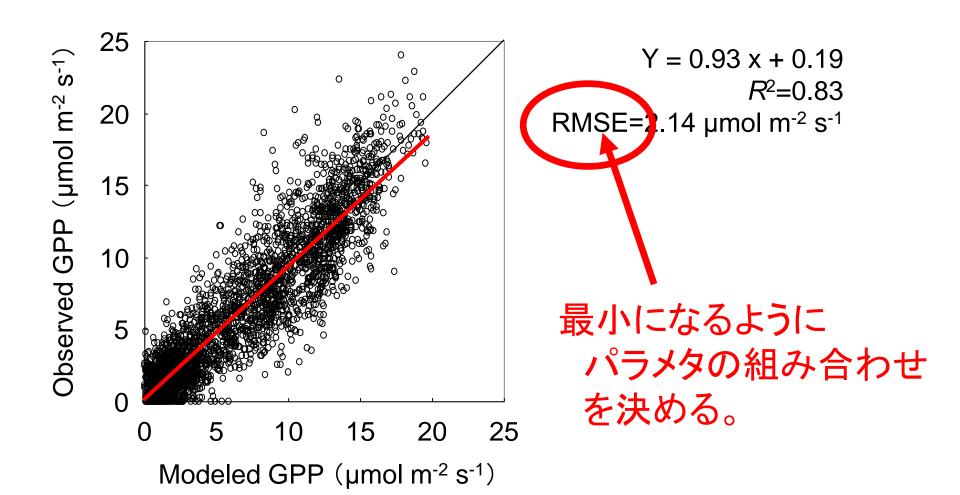
モデル パラメタ1 パラメタ2 パラメタ3



/ 出*刀*/ (観測データ)/



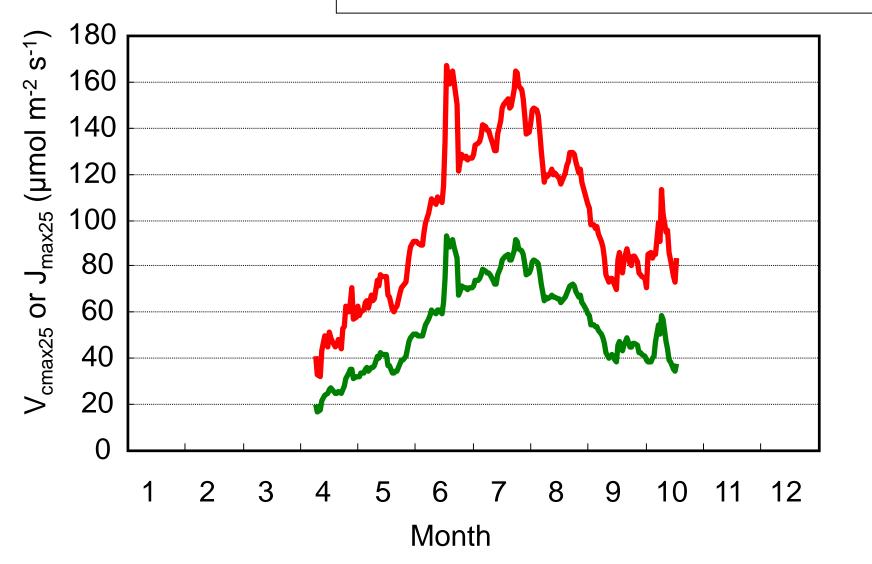
モデルの最適化 (パラメタの決定)



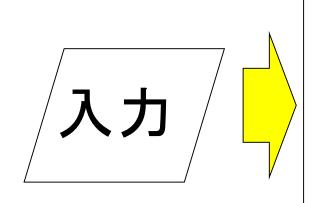
モデルの最適化

J_{cmax25} (最大電子伝達速度)

V_{cmax25} (最大カルボキシル速度)

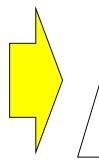


逆解析

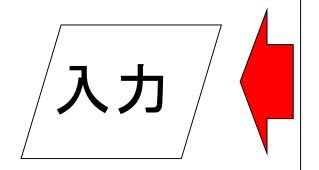




ハフメタ1 パラメタ2 パラメタ3

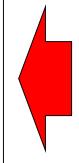


出力



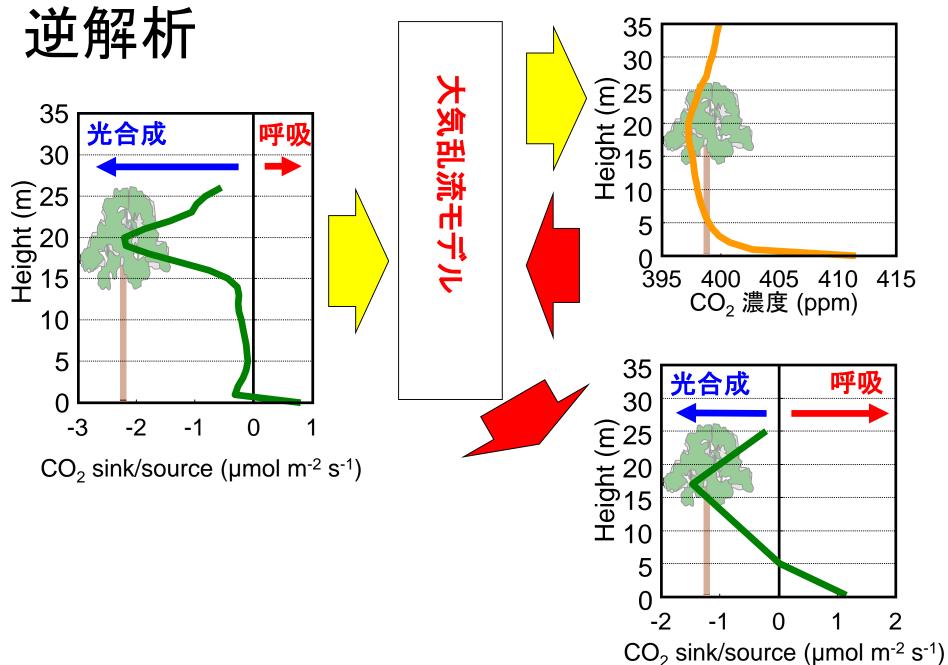
モデル

パラメタ1 パラメタ2 パラメタ3

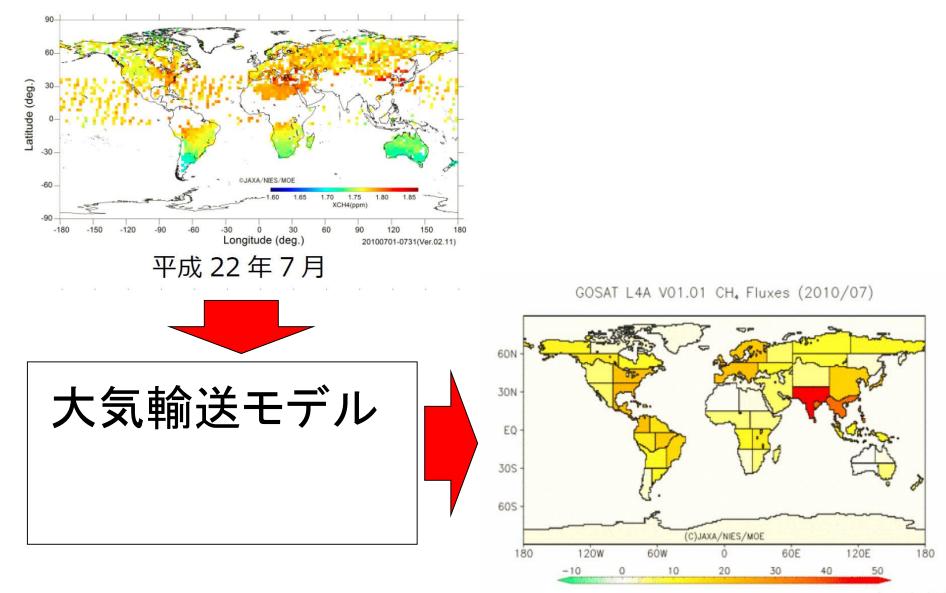


出力

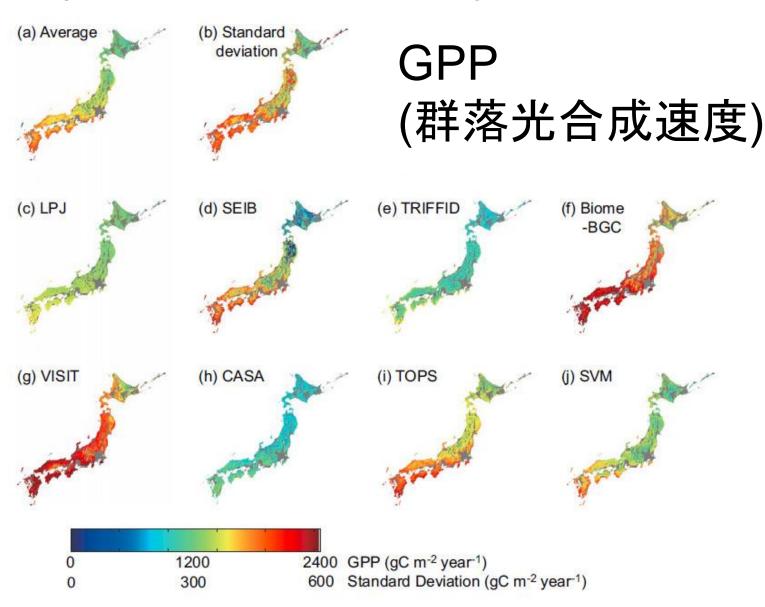
(観測データ)



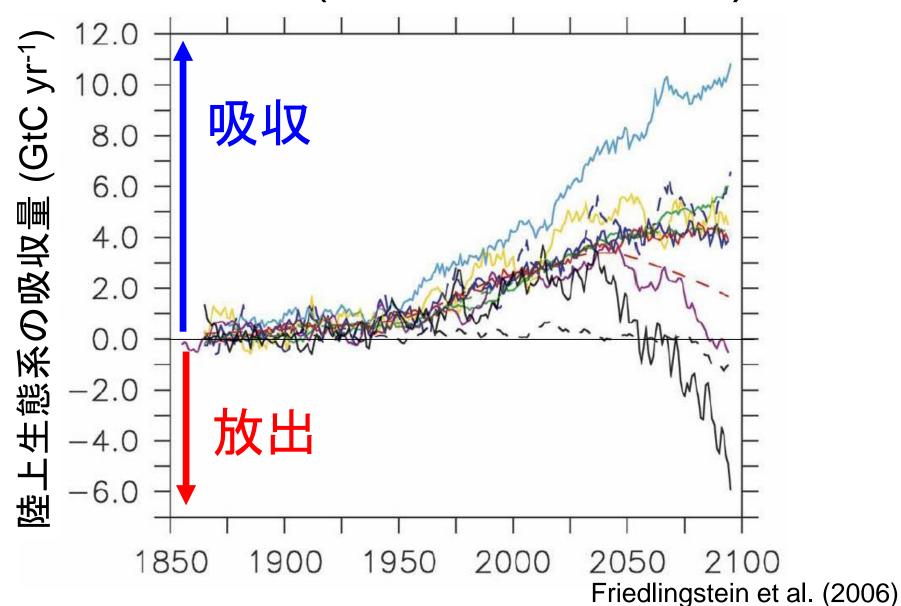
逆解析 ーGOSATプロジェクト



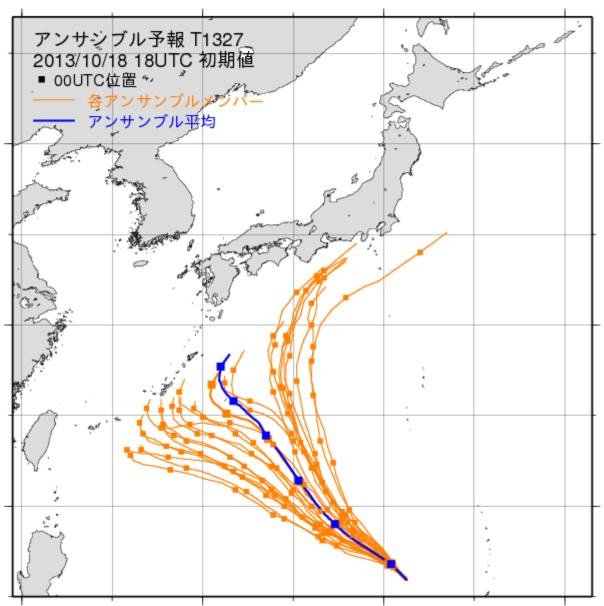
MIP(モデル相互比較)



予測 -MIP(モデル相互比較)



アンサンブル予測



(http://www.jma.go.jp/jma/kishou/know/whitep/1-3-8.html)

復習事項_

□ コンセプトモデル、経験モデル プロセスモデル (特徴、利点、欠点)

要因分析、最適化、逆解析

■ 当てはまりの評価法

☑ 生態系モデル ー結合モデル

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