IGSM2 Enhancements (Version 2.0)

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Categories of Enhancements to IGSM2

- Enhancements in theory and numerical methods
- Changes in source code to enhance the portability and applicability
- Improvements in the input and output files for clarity; additional output files for the extraction of simulation results; improved documentation
- Additional features that can be utilized during simulation

Modifications/Improvements in IGSM2 v2.0

- Any time step can be used
- Dynamic dimensioning of Fortran arrays (allows efficient use of memory and avoids re-dimensioning of arrays at compile time for individual applications)
- Options to print out tile drain hydrographs, boundary node flows, vertical flows between layers and simulation results at the last time step
- Improvements in computation and appearance of budget tables

Theoretical Enhancements in IGSM2 v2.0: *Groundwater, Streams and Lakes*

- Solution of non-linear groundwater equation
- Changes and improvements in the simulation of stream flows and lake storages
- Non-linear stream-groundwater and lake-groundwater interactions
- Simultaneous solution of groundwater, stream and lake equations using fully-implicit method and Newton-Raphson linearization technique for robust computation of interactions among these components

Theoretical Enhancements in IGSM2 v2.0:
Groundwater, Streams and Lakes (continued)

- **Coupled stream, lake and groundwater equations:**

$$\left.\begin{aligned}\left[X_s^{t+1}\right]\left\{h_s^{t+1}\right\}+\left\{F_s^{t+1}\right\}=0\\ \left[X_{lk}^{t+1}\right]\left\{h_{lk}^{t+1}\right\}+\left\{F_{lk}^{t+1}\right\}=0\\ \left[X_g^{t+1}\right]\left\{h_g^{t+1}\right\}+\left\{F_g^{t+1}\right\}=0\end{aligned}\right\}\Rightarrow\left[X^{t+1}\right]\left\{H^{t+1}\right\}+\left\{F^{t+1}\right\}=0$$

$$\left\{H^{t+1}\right\}^T=\left\{h_{s_1}^{t+1},\cdots,h_{s_{NS}}^{t+1},h_{lk_1}^{t+1},\cdots,h_{lk_{NLK}}^{t+1},h_1^{t+1},\cdots,h_{N\times N_L}^{t+1}\right\}$$

Theoretical Enhancements in IGSM2 v2.0:
Groundwater, Streams and Lakes (continued)

- **Newton-Raphson iteration technique for the solution of coupled system of equations:**

$$\left[\left(X^{t+1}\right)^{k}\right]\left\{\left(\Delta H^{t+1}\right)^{k+1}\right\}=\left\{\left(F^{t+1}\right)^{k}\right\}$$

$$\text{where } \left(\Delta H_i^{t+1}\right)^{k+1}=\left(H_i^{t+1}\right)^{k+1}-\left(H_i^{t+1}\right)^{k}$$

$$\left(F_i^{t+1}\right)^{k}=\sum_{j=1}^{N\cdot m}\left(X_{i,j}^{t+1}\right)^{k}\left(H_j^{t+1}\right)^{k}+\left(F_i^{t+1}\right)^{k}$$

$$\left(X_{i,j}^{t+1}\right)^{k}=\left(\frac{\partial F_i^{t+1}}{\partial H_j^{t+1}}\right)^{k}$$

Theoretical Enhancements in IGSM2 v2.0: *Water Demand and Supply*

- Irrigation fractions for pumping and surface water diversions are defined as time series data
- Program termination if water supply is specified for agricultural or urban area where such area is zero
- Iterative computation of actual pumping amount at drying wells for proper computation of water supply to agricultural and urban areas

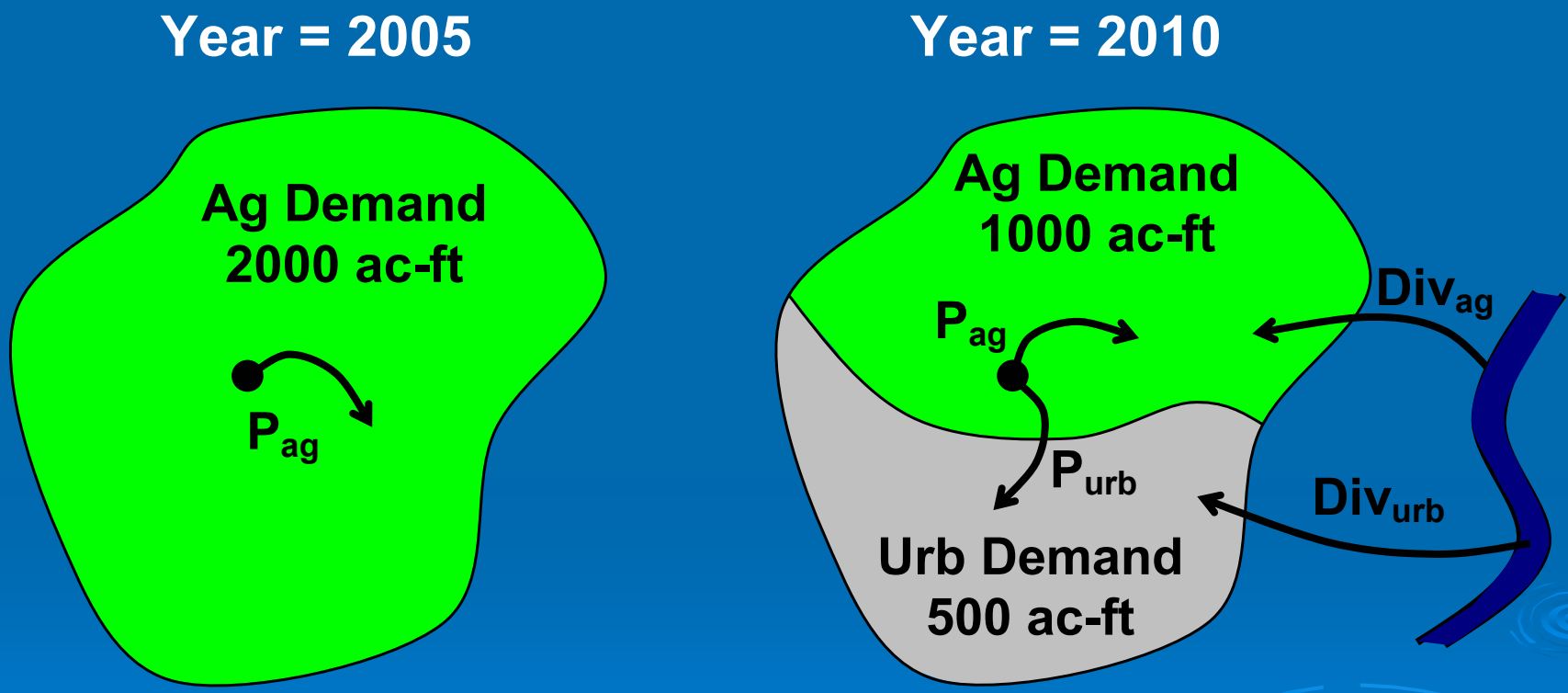
Theoretical Enhancements in IGSM2 v2.0: *Automated Adjustment of Water Supply*

- Stream diversions and/or groundwater pumping can be adjusted to minimize the discrepancy between the water demand and supply
- Diversions and pumping can be adjusted to meet only agricultural demand, only urban demand, or both
- Adjustment of diversions and pumping can be pre-specified to turn on or off throughout the simulation period
- IGSM2 proportionally distributes the difference between the demand and supply among adjusted diversions and pumping

Theoretical Enhancements in IGSM2 v2.0: *Automated Adjustment of Water Supply (cont.)*

- IGSM2 adjusts "required" amount of diversions and pumping to meet the demand; there can still be shortages depending on the availability of water in the system
- Adjustment of supply is performed until the ratio of actual supply to the demand is smaller than a user-defined tolerance value
- Irrigation fractions specified by the user are altered during supply adjustment

Theoretical Enhancements in IGSM2 v2.0:
Automated Adjustment of Water Supply (cont.)



Future Enhancements

- Computation of velocity field based on simulated groundwater head field to report mass balance at individual nodes *(in progress)*
- Choice of solvers for matrix equations *(partially completed)*
- Option to run IGSM2 simultaneously for adjacent model areas
- Inclusion of reservoir simulation and water rights module